SEMINAR ON

CERAMIC

INDUSTRY RAW MATERIALS & ESSENTIAL INPUTS

Organised by

iNDEXTb

Industrial Extension Bureau

A Govt. of Gujarat Organisation

13.03.1993

VENUE

Thakorbhai Hall, Near Law College Road, Ellisbridge
Ahmedabad- 380 006

Co-sponsors

1. Gujarat Ceramic Industry Development Board
2. Directorate General of Technical Development
3. All India Pottery Manufacturers Association

Gujarat Ceramic Industries Development Board

Mr. M. P. Pareliwala	President
Mr. Vishnubhai B. Patel	Member
Mr. H. P. Vyasa	Member
Mr. Rupesh C. Shah	Member
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Mr. Gopalbhai Patel	Member
Mr. Dhirubhai Patel	Member

Seminar Organising Committee Members

(1)	Shri C. K. Joshi	Director, Directorate of Geology & Mining
(2)	Shri G. B. Shah	Managing Director, Jay Minerals 48, Sharda Society, Ahmedabad-380 007.
(3)	Shri J. V. Bhatt	Sr. Development Officer (Minerals) Industrial Extension Bureau, Government of Gujarat Organisation.
(4)	Shri B. D. Kothari	Executive Director, Madhusudan Industries- Ceramic Division.
(5)	Shri V. G. Malkan	Ex-Chief Chemist
(6)	Shri Vishnubhai Patel	Member of Gujarat Ceramic Industry Development Board.
(7)	Shri H. P. Vyasa	National Institute of Design, Ahmedabad.
(8)	Shri K.V.K. Raju	Small Industries Service Institute, Ahmedabad.
(9)	Shri A. K. Oza	General Manager (Tech.) Industrial Extension Bureau, Govt. of Gujarat Organisation Ahmedabad-380 009.
(10)	Shri R. J. Shah	Chief Industrial Advisor, Govt. of Gujarat, Executive Director, iNDEXTb

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OBJECTIVE OF THE SEMINAR

Shri B. D. Kothari
Executive Director
Madhusudan Industries, Ceramic Division
& Convener Raw Material Committee
DGTD Development Panel on Ceramic Industry,
President, All India Pottery Manufacturers Association.

The Raw Materials Sub-Committee of the reconstituted DGTD Development Panel for Ceramic Industry was specifically formed to look into the present status of the various important raw materials and other inputs, problems being faced by the various ceramic industries in respect of quality and quantity and how best these can be sorted out.

During thye deliberations the following situation emerged :

i) Though all the essential raw materials, barring one or two, are available in the country, it is rather unfortunate that they have not been fully and properly explored to suit the qualitative and quantitative needs of the ceramic industry.

ii) Availability of the raw materials and mine-owners/suppliers being limited there seems to be a monopolistic situation resulting in supply of poor, inconsistent and irregular supplies.

iii) Improvement in quality is totally neglected.

iv) Exorbitant increase in prices at regular intervals by the mine-owners.

v) Mining rules of the government permits mine-owners to hold on to the leasing at hardly any cost without any production in the mines.

vi) Large area of mines is leased out and remain unexplored and unutiliseed.

vii) All these are causing inferior quality products particularly in comparison to the developed countries and the ceramic products thus produced is neither cost effective nor of proper quality for the purpose of exports in the globally competitive market.

Enclosed is a statement of major raw materials used by the ceramic industry giving qualitative requirement vis-a-vis ISI specifications. The difficulties expressed during the deliberations are given under each item, wherever applicable. The specifications may be further debated and finalised, so also way and measures to achieve them.

Following approach to tackle the problem was though of :

i) It is necessary to get the version of the suppliers and have inter-action with them by way of Buyer-Seller Meets with a view to improve the situation.

CERAMIC RAW MATERIALS OF INDIA

C. K. Joshi, V. G. Malkan
Directorate of Geology & Mining, Government of Gujarat,

J. V. Bhatt
"iNDEXTb", Govt. of Gujarat Organisation

An attempt has been made in forgoing para for covering the principal raw materials used by Ceramic industry. Principal raw materials for which information has been collected are Bauxite, Bentonite, China clay, Pyrophyllite, Quartz, Talc etc.

The minerals are backbone of the country. Number of ceramic industries are set up in almost all parts of the country.

In India whiteware industry is dominant. But to have good quality of whiteware articles, we must have good quality of raw materials.

Uptil now trend is to use ceramic raw materials as it occurs. But for better quality product it is almost necessary to have modified, treated or blended raw materials. We hope that data presented here will be useful in achieving this objective.

QUARTZ

Quartz is used in Ceramic industry to reduce shrinkage in drying and firing and to impart rigidity to the body. Iron is most deletrious constituent and should be as less as possible. If Fe_2O_3 is more that 0.1% dot will form on the ceramic body and in the case of electrical insulator current may pass. In general, silica should be 97 - 99.9%, FeO_3 to 1), Al_2O_3 0.1% - 2%.

Quartz, Quartzite and Silica sand

Specification :
Ceramic & Pottery

SiO_2	(+) 97%
Fe_2O_3	0./4 to 1.25%
Al_2O_3	Should be less i.e. 2% Max.

PRODUCTION

Quartz

(Quantity in tonnes)

Sr. No.	State	1986	1987	1988	1989
1	2	3	4	5	6
1.	Andhra Pradesh	118031	95964	62723	738800
2.	Bihar	1235	3572	6942	5472
3.	Gujarat	16389	8081	3055	5575
4.	Haryana	536	257	3987	-
5.	Karnataka	18886	42597	57102	68234
6.	Madhya Pradesh	240	120	10	-
7.	Maharashtra	9652	13024	21133	18676
8.	Orissa	129	1450	-	-
9.	Rajasthan	46997	49250	40768	50296
10.	Tamil Nadu	16417	14460	9430	8083
	Total All India	228512	228775	205150	230226
Quartzite					
1.	Bihar	15115	13876	15271	6894
2.	Madhya Pradesh	10658	19734	36735	41861
3.	Orissa	61379	35748	53473	42952
4.	Rajasthan	706	1231	1591	1455
	Total All India	87858	70589	107070	93162
Silica sand					
1.	Andhra Pradesh	39602	40130	39470	63464
2.	Bihar	61421	47953	84572	80156
3.	Gujarat	131195	99069	114403	103501
4.	Haryana	72083	667452	638386	175843
5.	Karnataka	92119	114028	125157	65983
6.	Kerala	49743	54343	46979	45281
7.	Madhya Pradesh	10615	11030	14904	24882
8.	Maharashtra	170913	167492	167234	194088
9.	Rajasthan	156880	185360	202289	196525
10.	Tamil Nadu	193	294	1269	697
11.	Uttar Pradesh	246267	216958	187088	154326
Total All India		1031031	1604109	1621751	1104746

CHEMICAL ANALYSIS

Source	Constituents (%)									
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	L.O.I	Carbon
Elllore (C)	57.32	28.89	1.26	1.05	0.27	0.34	1.25	0.08	10.10	0.20
Punyaksshee-tram (C) Andhra Pradesh	52.85	29.42	2.44. 3.20	0.26	Tr	0.29	0.17	0.14		
Rajhara (C) Bihar	61.80	24.02	0.59	1.63	1.26	Tr	0.31	0.53	9.90	0.48
Bikaner (C) Rajasthan	54.36	30.58	1.98	1.86	0.05	Tr	0.77	0.19	10.45	0.18
Padappakara (C) Kerala	55.80	28.93	1.28	1.31	Tr	0.40	0.04	0.14	11.98	0.47
Kumbalam (C) Kerala	48.26	34.00	1.84	1.66	Tr	0.31	0.08	0.06	13.80	0.80
Ramapuram (C) Kerala	45.22	31.98	3.17	1.33	0.49	Tr	1.00	2.11	14.70	-
Botia (C) Rajasthan	59.68	25.66	1.17	3.05	0.27	Tr	0.13	0.23	9.98	-
Expressed(P)	45.90	37.74	0.57	0.69	0.76	0.18	-	-	14.13	0.10
Bilaspur No. 1 Madhya Pradesh (P)	63.01	23.73	0.86	1.80	0.35	Tr	0.67	0.10	9.79	0.70
Neyveli while (P) Tamil Nadu	46.05	37.87	0.83	1.00	0.09	0.12	0.26	0.02	14.04	0.08
Rajpardi (C) (Gujarat)	42.33	35.35	2.44	3.56	0.87	0.07	0.03	0.40	14.50	-
Than (C) Gujarat	62.23	23.93	0.94	1.67	0.21	Ab	0.25	0.58	9.74	-
Santhalpur (C) Gujarat	57.78	28.23	1.81	1.67	0.21	Ab	0.41	0.21	9.84	-

C = crude P = processed

ACKNOWLEDGEMENT

Authors are thankful to Shri H. K. Navadiya, Shri K.D. Shukla &Shri A.D. Trivedi for the help they have rendered in preparation of this article.

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CHEMICAL ANALYSIS

Source		Constituents (%)								
Source		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	LOI
1		2	3	4	5	6	7	8	9	10
I.	**West Bengal**									
i)	Mokhdumnagar	43.64	35.58	2.39	2.64	1.80	Tr	0.13	0.36	13.50
ii)	Mahatomara	46.05	35.49	1.36	2.11	0.28	0.20	0.27	0.03	13.86
iii)	Mahammad Bazar	44.31	36.97	2.11	0.80	0.31	0.26	0.60	0.29	14.34
II.	**Bihar**									
i)	Rajmahal	47.53	38.69	0.59	0.88	0.18	Tr.	0.13	0.10	12.37
ii)	Ulatu	44.53	38.51	0.55	1.23	0.23	0.05	0.05	0.11	14.77
iii)	Samukhia	51.14	31.90	0.29	0.34	1.27	0.85	1.35	1.01	11.90
III.	**Meghalaya**									
i)	Darugiri	48.35	34.18	0.98	1.18	0.47	Tr	0.13	0.24	14.13
IV.	**Orissa**									
i)	Mayurbanj	48.55	33.69	1.45	0.53	Tr	1.27	-	0.17	11.16
V.	**Kerala**									
i)	Kerala Illite	47.08	37.12	0.86	0.70	Tr	Tr	-	-	13.08
VI.	Tamil Nadu									
i)	Neyveli clay	44.95	36.72	0.38	1.75	0.56	Tr	0.03	0.24	14.24
VII.	Rajasthan							Na_2O+K_2O		
i)	Chittorgarh	58.35	27.79	0.85	-	-	-	0.66		9.60
ii)	Sawa	66.78	23.59	1.31	-	-	-	1.33		5.66

RESERVES
(Kaolin, Ballclay & Other clays) as on 1.1.1985

(Quantity in '000 tonnes)

1.	Andhra Pradesh	23,584
2.	Assam	3,698
3.	Bihar	41,786
4.	Delhi	5,648
5.	Goa	15
6.	Gujarat	3,784
7.	Haryana	509
8.	Jammu & Kashmir	19,641
9.	Karnataka	10,943
10.	Kerala	89,398
11.	Madhya Pradesh	17,951
12.	Maharashtra	3,258
13.	Meghalaya	57,086
14.	Orissa	93,803
15.	Pondichery	2,352
16.	Rajasthan	208,072
17.	Tamil Nadu	46,218
18.	Tripura	91
19.	Uttar Pradesh	12
20.	West Bengal	249,725
	Total - All India	871,574

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10
ii)	Mamuar Kachchh	White	4.0	Moderate to fair	38.50	-	-	-	-	-
iii)	Eklera Mehsana	Pale white	6.0	Good	39.21	-	-	-	-	-
iv)	Arsodia Mehsana	Pale white	5.0	Good	33./27	-	-	-	-	-
v)	Bavli Surendranagar	White	5.0	Moderate	26.93	-	-	-	-	-

PHYSICAL PROPERTIES (FIRED)

		Sample fired at 1250°C				Sample fired at 1400°C				
	Source	Colour	% Linear Shri-nkage	Vitri-fica-tion	% Water absor-ption	Colour	% Linear shri-nkage	Vitri-fica-tion	% Water absor-ption	PCE value in orton cone
	1	2	3	4	5	6	7	8	9	10
I.	**West Bengal**									
i)	Mokhadumnagar	Dull cream	18.0	High	3.20	Light brown	20.0	High	1.5	32 - 34
ii)	Mohatomara	Pale while.	16.0	None	14.70	Dull pale.	20.0	Fair	5.1	35 - 35
iii)	Mohamad Bazar	Light Cream	16.0	None	13.80	Pale cream.	20.0	High	2.3	32 - 33
II.	**Bihar**									
i)	Rajmahal	White	14.40	None	15.40	White	18.00	Fair	4.3	35 - 35
ii)	Ulatu	Very white	14.00	None	16.6	Pale white	17.0	Fair	5.2	34 - 35
iii)	Samukhia	White	16.0	None	14.8	White	20.0	Fair	3.8	34 - 35

Seminar
on
Ceramic Industry Raw Materials & Essential Inputs

Programme

Venue : Thakorebhai Hall, Near Law College, Ahmedabad-380 006.

Inauguration Sessions - (9.00 A.M. to 11.00 A.M.)

I	Welcome Address	Shri M. N. Buch, I.A.S. Industries Commissioner Government of Gujarat
II	Inauguration	Shri Shashikant Lakhani Hon. Minister for Cottage, Industry, Mines, Printing and Industry. Government of India
III	Key-note Address	Shri Sanatbhai Mehta, Chairman, Gujarat Finance Commission Government of Gujarat
IV	Seminar Highlights	Shri B. D. Kothari, Executive Director, Madhusudan Industries Ltd., Ceramic Division.
V	Vote of Thanks	Shri R. J. Shah, Chief Industrial Advisor, Government of Gujarat/ Executive Director "iNDEXTb" A Govt. of Gujarat Organisation.

Tea Break - (11.00 A.M. to 11.15 A.M.)

Technical Session

Technical Session-I	11.30 A.M. to 1.00 P.M.
1.00 P.M. to 2.00 P.M.	(Lunch Break)
Technical Session II & III	2.00 P.M. to 4.30 P.M.
4.30 P.M. to 5.00 P.M.	(High Tea)

Seller-Buyer Meet Concluding Session 5.00 P.M. to 6.00 P.M.

	1	2	3	4	5	6	7	8	9	10
III.	**Meghalaya**									
i)	Darugiri clay	Very white	12.0	None	21.70	White	14.0	None	13.80	34 - 35
IV.	**Tamil Nadu**									
i)	Neyveli clay	White	16.2	None	8.6	Dull white	20.0	Fair	2.8	33 - 34
V.	Gujarat									
i)	Balaniwav, Amreli	Light cream	22.00	Fair	-	sun-shine	22.0	High	-	-
ii)	Mamuaro, Kachchh	White light	19.0	None	-	White brown	21.0	Fair	-	-
iii)	Eklera, Mehsana	White with brown specks.	16.0	None	-	White brown	17.0	Fair	-	-
iv)	Arsodia, Mehsana	White	11.0	None	-	White	14.0	None	-	-
v)	Bavli Surendranagar	Pale white with small brown specks.	9.0	None	11.09	Beige	13.0	High	2.16	-

RESERVES
(as on 1.1.1985)

(In million tonnes)

1.	Andhra Pradesh	455.84
2.	Bihar	63.52
3.	Goa	32.26
4.	Gujarat	87.42
5.	Jammu & Kashmir	3.29
6.	Karnataka	27.00
7.	Kerala	8.63
8.	Madhya Pradesh	126.81
9.	Maharashtra	87.72
10.	Orissa	1370.45
11.	Rajasthan	0.54
12.	Tamil Nadu	17.21
13.	Uttar Pradesh	9.42
	Total All India	2290.11

PRODUCTION

(Quantity in tonnes)

State	1987	1987	1988	1989	1990
Bihar	767703	869219	826453	721764	859009
Gujarat	467052	445435	415738	549359	805159
Jammu & Kashmir	19	-	36	12	-
Karnataka	39322	30708	18501	19301	55087
Madhya Pradesh	660121	593959	542139	485879	499692
Maharashtra	413538	368676	535053	538509	560838
Orissa	238915	420229	1539810	2045219	1853117
Tamil Nadu	62534	80602	75094	83170	115836
Uttar Pradesh	1649	-	-	-	-
Goa	11547	5050	7975	28245	24676
Total All India	2662200	2813878	3960799	4471458	4773414

CONSUMPTION

(In tonnes)

	1986	1987	1988
Abrasive	71347 (8)	78081 (8)	71769 (8)
Ceramics	3259 (8)	1521 (7)	1778 (7)
Refractory	161898 (31)	173833 (36)	180622 (36)

NB : Figure given in brackets indicates number of units

ii) Though the Indian Bureau of Mines publish data regarding availability of various raw materials areawise, it was thought that various State governments, particularly those who are rich in ceramic raw materials, be approached to give a comprehensive information regarding availability of the raw materials in their States together with the specifications and names of the suppliers.

iii) Inter-action with the various research institutions to explore how best they can assist in the matter.

To meet the above objectives it was thought fit to organize two Seminars in the mineral rich States - one in Gujarat and another in Andhra Pradesh - on Ceramic Raw Materials and other essential inputs for Ceramic Industry.

Industrial Extension Bureau of Government of Gujarat was approached to organize the Seminar in Gujarat which they readily agreed. The government of Andhra Pradesh is also seriously considering to organize a similar Seminar.

It was also thought fit to include the following essential inputs for ceramic industry for deliberations at the Seminar.

a) Fuel

b) Recent trends in kiln technology, and kiln furniture, and

c) Frits, glazes and pigments.

Attempts have been made to arrange Technical Papers and collection of data on all subjects and compile them in the form of a Souvenir. Presentation of these Papers in the Seminar will enable a fruitful discussion and will also serve as a good reference material.

It is hoped that the Seminar will go a long way in crystallizing the present status as also the steps that should be taken to improve the situation.

CHEMICAL ANALYSIS

No.	Source	Constituents (%)								
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	LOI
1.	Mihijam, Bihar	65.90	19.34	0.29	0.04	0.35	Tr	9.27	8.07	0.04
2.	Kodarma, Bihar	64.00	18.83	0.30	-	0.55	-	12.02	3.11	0.21
3.	Alwar (1) Rajasthan	65.56	20.93	0.12	-	2.05	Tr	7.12	3.49	0.42
4.	Alwar (2) Rajasthan	64.96	19.62	0.11	-	0.34	Tr	11.25	2.72	0.86
5.	Jhansi, Madhya Pradesh	63.69	21.88	0.24	-	0.34	-	11.25	2.72	0.86
6.	Nellore, Tamil Nadu	64.80	19.09	0.20	-	0.18	0.01	13.00	2.40	0.50
7.	Sitampudi, Andhra Pradesh	44.84	34.07	0.05	-	20.05	0.50	-	-	-
8.	Raghudi, West Bengal	64.70	19.54	0.36	-	-	-	11.42	2.46	-
9.	Taraboni, West Bengal	64.79	17.70	0.60	-	-	-	14.28	2.00	-
10.	Ambari, West Bengal	-	-	0.32	-	-	-	12.58	2.50	-
11.	Tura, Meghalaya	64.93	19.68	0.12	-	-	0.08	9.61	5.22	0.26
12.	Hamia, Meghalaya	62.12	18.95	0.46	-	0.05	-	10.28	5.90-	-

CHEMICAL ANALYSIS

Source	Constituents (%)								+
	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	K2O	Na2O	L.O.I.
Quartz									
Nizamabad, Andhra Pradesh	99.75	0.15	0.02	-	-	-	-	-	
Hyderabad, Andhra Pradesh	99.96	-	0.02	-	-	-	-	-	
Tura, Meghalaya	99.12	0.21	0.36	0.01	-	-	-	-	-
Panchmahal, Gujarat	99.52	0.12	0.01	-	0.08	Tr	0.01	0.02	0.15
Quartzite									
Jamda, Bihar	99.72	0.04	0.06	-	Tr	-	-	-	0.12
Mithijam, Bihar 98.76	0.84	0.10	0.02	0.22	Tr	0.11	Tr	Tr	
Hyderabad, Andhra Pradesh	99.28	0.20	0.04	Tr	0.24	Tr	Tr	Tr	Tr
Panchmahal, Gujarat	97.66	1.18	0.37	-	0.12	-	-	-	0.50
Silica sand									
Jaijan, Punjab	99.20	0.62	0.09	-	Tr	0.05	-	-	0.15
Arongpur, Haryana	99.62	0.21	1.40	-	1.14	0.12	-	-	-
Sawai Madhopur, Rajasthan	99.22	-	0.08	-	-	-	-	-	-
Samod, Rajashthan	99.14	-	0.08	-	-	-	-	-	-
Jogendranagar, Tripura	95.51	3.00	0.57	-	0.27	.017	-	-	-
Nowang, Assam	98.33	0.08	0.21	Tr	0.10	0.03	0.16	-	
Amod, Gujarat	97.35	0.92	0.30	0.43	0.21	-	Ab	0.03	0.54
Damali, Gujarat	97.04	0.70	0.47	0.33	0.21	0.02	Ab	0.04	0.72
Himmatnagar, Gujarat	98.31	0.74	0.07	0.15	0.14	Tr	0.01	0.02	0.15
Ongliyana, Gujarat	97.66	1.14	0.10	0.10	0.01	0.10	0.02	0.01	0.75
Rajpardi, Gujarat	93.19	2.39	0.63	0.58	0.71	Ab	0.01	0.04	1.66

PLASTIC CLAY

The Plastic clay is a sedimentary clay. It imparts high green strength and good workability to pottery bodies.

The primary mineral phase is disordered kaolinite. Micaceous minerals and quartz are present as main impurities. Minor amounts of Feldspar, Montmorillonite, Titanium compounds, Siderite, Pyrite etc. is also present.

Normally plastic clay used approximately as under:

Viterous sanitary ware	10 to 40%
Hotel China	7 to 15%
Floor & Wall tiles,	10 to 35%
Electrical porcelain	20 to 45%
Semi Vitreous white ware	

Specification (IS : 4589-1979)

		Requirements		
		Grade-1	Grade-2	Grade-3*
Physical requirements :				
i)	Fired colour	White to light cream or light grey & free from specks or patches.	Light cream to dull cream or light grey and free from specks and patches	
ii)	Grit content (residue on 45 microns IS sieve) percent by mass, max.	2	3	-
iii)	Particle size distribution percent by mass:			
(a)	Coarser than 25 microns (Max.)	3	6	9
(b)	Finer then 2 Microns (Min.)	75	65	40
iv)	Water of plasticity percent by mass, Min.	40	28	25

Consumption

(In tonnes)

	1986	1987	1988
Ceramic (Quartz & Sillica sand)	37640 (40)	44044 (40)	44694 (40)
Refractory (Quartzite)	78974 (9)	62302 (10)	90608 (10)

RESERVES

Quartz, Quartzite & Sillica sand
(as one 1-1-1985) (In tonnes)

1.	Andhra Pradesh	25,204
2.	Assam/Kabri Anglong Nowgong	1,253
3.	Bihar	148,273
4.	Goa	22,891
5.	Gujarat	28,762
6.	Haryana	117,378
7.	Himachal Pradesh	2,049
8.	Jammu & Kashmir	2,177
9.	Karnataka	29,208
10.	Kerala	116,868
11.	Maharashtra	48,693
12.	Madhya Pradesh	1,397
13.	Meghalaya	2,303
14.	Orissa	2,853
15.	Punjab	17,750
16.	Tamil Nadu	70,991
17.	Tripura	313
18.	Uttar Pradesh	57,340
19.	West Bengal	1,288
	Total All India	779,929

PHYSICAL PROPERTIES

Source	Plasticity by hand-feel	Atterberg's Number	Water of plasticity %		Dry linear shrinkage on plastic length (%)
			Dry basis	Plastic basis	
Andhra Pradesh					
Ellore	Good	13	36.30	26.60	6.0
Punyakshetram	Good	15	33.20	24.9	5.6
Bihar					
Rajhara	Fair	13	24.30	19.60	7.2
Rajasthan					
Bikaner	Very good	20	33.70	25.20	8.0
Botia	Fair	12	25	-	5.60
Kerala					
Padappakara	Very good	45	-	-	8.0
Kumbalam	very good (Sticky)	50	-	-	10.7
Expressed	Good	12	41.7	29.7	4.8
Madhya Pradesh					
Bilaspur No. 1	Good	8	24.6	19.50	6.00
Tamil Nadu					
Neyveli white	Good	11	28.0	21.90	2.00
Gujarat					
Rajpardi	Fair	-	38.52	-	5.0
Than	Fair	-	26.26	-	5.0
Santhalpur	Fair	-	31.19	-	5.0

CHINA-CLAY

China clay also called Kaolin is one of the essential raw material in the ceramic industry which consumes bulk of indigenous production.

For the manufacture of ceramic products good quality china-clay is required.

This china-clay may be primary, secondary or residual in origin. Secondary clays are impure while primary clays are siliceous and gritty. Both types of the clays are used by ceramic industry.

Specification : (IS : 2840-1985)

		Requirements	
		Grade-I	Grade-II
i)	Finess (residue on 44 microns IS-sieve percent by weight max.)	1.0	2.0
ii)	Loss on ignition percent by weight Min.	12	10.5
iii)	Alumina (as Al_2O_3) percent by weight (min.)	36	30
iv)	Oxides of iron (as Fe_2O_3) percent by weight max.	1.0	1.50
v)	Titanium oxide (as TiO_2) percent by weight max.	0.70	1.50
vi)	Oxides of iron (as Fe_2O_3e) and Titanium oxide (as TiO_2) together 33percent by weight max.	1.50	2.75
vii)	Water if plasticity percent min.	22	22
viii)	Shrinkage linear a) Dry shrinkage at 110°C percent Max.	8	8
	b) Fired shrinkage (at segar cone 12) percent max.	18	18

CHEMICAL ANALYSIS

	Constituents (%)									
Source	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	LOI	Carbon
Ellore (C)	57.32	28.89	1.26	1.05	0.27	0.34	1.25	0.08	10.10	0.20
Punyaksshee-tram(C) Andhra Pradesh	52.85	29.42	2.44	3.20	0.26	Tr	0.29	0.17	11.24	0.14
Rajhara (C) Bihar	61.80	24.02	0.59	1.63	1.26	Tr	0.31	0.53	9.90	0.48
Bikanar (C) Rajasthan	54.36	30.58	1.98	1.86	0.05	Tr	0.77	0.19	10.45	0.18
Padappakara (C) Kerala	55.80	28.93	1.28	1.31	Tr	0.40	0.04	0.14	11.98	0.47
Kumbalam (C) Kerala	48.26	34.00	1.84	1.66	Tr	0.31	0.08	0.06	13.80	0.80
Ramapuram (C) Kerala	45.22	31.98	3.17	1.33	0.49	Tr	1.00	2.11	14.70	-
Botia (C) Rajasthan	59.68	25.66	1.17	3.05	0.27	Tr	0.13	0.23	9.98	-
Expressed (P)	45.90	37.74	0.57	0.69	0.76	0.18	-	-	14.13	0.10
Bilaspur No.1 Madhya Pradesh (P)	63.01	23.73	0.86	1.80	0.35	Tr	0.67	0.10	9.79	0.70
Neyveli white (P) Tamil Nadu	46.05	37.87	0.83	1.00	0.09	0.12	0.26	0.02	14.04	0.08
Rajpardi (C) (Gujarat)	42.33	35.35	2.44	3.56	0.87	0.07	0.03	0.40	14.50	-
Than (C) Gujarat	62.23	23.93	0.94	1.67	0.21	Ab	0.25	0.58	9.74	-
Santhalpur (C) Gujarat	57.78	28.23	1.81	1.67	0.21	Ab	0.41	0.21	9.84	

C = crude P = processed

1		2	3	4	5	6	7	8	9	10
VIII. **Gujarat**										
i)	Balaniwav, Amreli	42.17	37.46	2.16	0.22	Ab	Ab	0.03	0.35	13.54
ii)	Mamuara, Kachchh	45.43	35.50	0.65	1.58	0.34	Nil	0.03	0.28	13.99
iii)	Eklera, Mehsana	46.34	32.64	1.12	1.04	4.18	0.31	0.36	0.22	14.26
iv)	Arsodia, Mehsana	50.34	34.52	1.00	0.50	0.77	Tr	0.20	0.38	11.78
v)	Bavli, Surendranagar	60.79	26.50	1.04	1.41	0.13	0.03	0.45	0.53	9.11

(In tonnes)

RESERVES
(as on 1.1.1985)

1. Bihar	61,01,500
2. Gujarat	790,46,039
3. Jammu & Kashmir	20,000
4. Rajasthan	190,630,958
'Total All India	275,798,497

PRODUCTION

(Quantity in tonnes)

Sr. No.	State	1984	1985	1986	1987	1988
1.	Bihar	3363	3090	3969	2976	3559
2.	Gujarat	85075	106687	63358	81721	145594
3.	Rajasthan	42600	51089	36800	34258	76800
	Total (All India)	131038	160866	104127	118955	225953

CONSUMPTION (In tonnes)

	1986	1987	1988
Ceramic	916(9)	1084(10)	1061(9)
Refractory	4948(10)	4377(9)	4693(9)

NB : Figure given in brackets indicates number of units

PRODUCTION

(In tonnes)

No.	Source	1986	1987	1988	1989
1.	Andhra Pradesh	30747	25888	31365	19494
2.	Bihar	58569	43811	44124	40259
3.	Gujarat	29912	47514	46073	49846
4.	Haryana	8417	8559	4079	11900
5.	Jammu & Kashmir	90	159	146	94
6.	Karnataka	11934	11842	10580	7077
7.	Kerala	62335	62042	84535	81512
8.	Madhya Pradesh	15573	24782	14276	20446
9.	Maharashtra	9783	5424	4664	3817
10.	Orissa	27900	30542	21033	21120
11.	Rajasthan	302920	253990	176167	147695
12.	Tamil Nadu	6377	5238	5013	6957
13.	West Bengal	133659	127802	120041	93897
14.	Delhi	49320	65749	48430	70407
	Total All India	747438	713022	6105526	574521

CONSUMPTION

(In tonnes)

	1986	1987	1988
Ceramic	79420(37)	96176(38)	142638(37)
Refractory	20368(21)	16098(23)	18323(23)

NB : Figure given brackets indicates number of units.

PHYSICAL PROPERTIES
(White burning bentonite data)

No.	Observation	Amreli Gujarat	Amreli Gujarat	Rajula Gujarat	Bihar	Akli Rajasthan	Hathi-ki-Dhani Rajasthan	Jaipur Rajasthan	Karauli
1	2	3	4	5	6	7	8	9	10
1.	Raw colour of lumps.	Brown	Light brown.	Pale white lumps occasionally showing greenish buff & light brown patches.	Mostly grey mixed with buff brown and dull cream.	Mostly light grey lumps with occassional buff patches & containing a few light brown lumps.	Greyish light brown.	Greenish pale cream.	Very light green lumps.
2.	Raw colour of powder.	-	-	Dull white	Pale brownish grey.	Light brown	Dull brown	Dull pale cream	Greenish pale cream.
3.	Fired colour at 1250°C (Cone 7)	Reddish chocalate while salty small specks appears.	Red symmetrical colour	Dark brown completely fused.	Dirty cream full minute brown speecks.	Deep brown bloated and cracked.	Deep brown bloated	Greenish light	Greenish light grey, bloated.
4.	Fired colour at 1400°C (Cone 14)	-	-	Blackish glassy mass.	Bloated cracked warped to buss colour.	Deep brown highly bloated and fused	Deep brown bloated and fused	Light grey highly bloated and fused.	Grey fused glassy mass.
5.	Fracture	-	-	Uneven	Uneven in hard lumps sub concloidal in soft lumps.	Uneven to earthy	Earthy	Irregular to even	Irregular.
6.	Hardness	-	-	Fairly hard -	Fairly hard	Soft	Soft	Soft in some portions and hard in major portions.	Hard
7.	Specific gravity	2.84	2.08	2.79	2.62	2.83	2.645	2.781	2.708

PHYSICAL PROPERTIES (UNFIRED)

	Source	Raw colour	% Dry linear shrinkage	Plasticity by hand feel	% Water of plasticity	Atterberg's No.	Dry Modulus of rapture (lbs/in)	Particle less than 2 µ%	% Yield on washing	% Brightness at 5040°A
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10
I.	**West Bengal**									
i)	Mokhadumnagar	Cream	6.0	Fair	35.70	13.0	168.0	80.80	24.00	65.0
ii)	Mohatomara	Light cream	6.0	Moderate to fair	41.3	13.0	136.0	68.0	35.0	68.0
iii)	Mohamad Bazar	Pale white.	7.0	Good	44.70	15.0	191.0	81.20	40.0	73.0
II.	**Bihar**									
i)	Rajmahal	White	6.0	Moderate to fair	38.6	13.0	142.0	71.0	10.0	81.0
ii)	Ulatu	White	6.0	Moderate	40.40	12.0	125.0-	70.60	17.0	86.0
iii)	Samukhia	White	5.0	Low	31.50	10.0	78.0	59.0	16.0	80.0
III.	Meghalaya									
i)	Darugiri clay	White	5.0	Moderate	38.3	12.0	127.0	72.60	30.0	83.0
IV.	**Tamil Nadu**									
i)	Neyveli clay	Dull white	5.0	Moderate to fair	42.20	14.0	218.0	71.80	30.0	72.0
V.	**Gujarat**									
i)	Balaniwav Amreli	Dull white	4.0	Fair	45.26	-	64.90	-	-	-

TALC

Talc is used in ceramics, that range from the highest quality electronic steatite products to the more common products such as floor and wall tile and pottery.

Ceramic products such as electronic steatite, ceramic cookware and other heat resistant items including space aeronautics requires talc as one of the constituent.

Talc/Steatite/Soapstone

Specifications : IS:10420-1982

Sr. No.	Characteristics	Requirements	
		Grade-I	Grade-II
i)	LOI % by mass max.	5.50	6.50
ii)	Silica (as SiO_2)% by mass, min.	60	56
iii)	Alumina (as Al_2O_3)% by mass, max.	1.5	2.5
iv)	Iron oxide (as Fe_2O_3)% by mass, max.	1.0	1.50
v)	Calcium oxide (as CaO) % by mass, max.	1.0	3.50
vi)	Magnesia (as MgO) % by mass, min.	30	28
vii)	Alkalies (as Na_2O + K_2O) % by mass, max.	0.40	0.50
Additional properties for Grade-I talc			
i)	Linear shrinkage (fired) % by length, max.	12.00	
ii)	Water absorption % by mass, max.	0.10	
iii)	Fired modulus of rupture µpa T min.	34	
iv)	Loss factor at IMC % max.	0.40	

BAUXITE

Bauxite is a mixture of the mineral gibbsite (Al203 3H20) boehmite (Al203 H2O) & diaspore (Al203 H2O). The important uses of bauxite are in the manufacture of refractories and abrasives.

Specification :

Refractory grade (IS : 10817 - 1984)

Constituent (%)

Al_2O_3	58 Min.
Fe_2O_3	3 Max.
TiO_2	3 Max.
CaO	0.5-0.6
L.O.I.	27 - 30

Abrasive grade :

Al_2O_3	50 min.
SiO_2	4 max.
Fe_2O_3	10 max.
TiO_2	3 max.

CHEMICAL ANALYSIS

Constituents (%)

Source	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	S_2O_3	P_2O_5	LOI
Kheda, Gujarat	4.70	55.74	4.84	3.17	0.07	0.17	0.03	0.85	-	-	30.39
Kachchh, Gujarat	3.62	60.96	2.40	2.40	0.83	Tr	-	-	-	-	28.81
Jamnagar, Gujarat	1.85	62.12	2.80	4.77	1.01	Tr	-	-	-	-	28.00
Belgaum, Karnataka	3.00	59.00	3.60	8.00	-	-	-	-	-	-	28.00
Katni, Madhya Pradesh	6.80	55.00	4.50	7.80	-	-	-	-	-	-	-
Kolaba, Maharashtra	1.27	59.27	4.94	4.10	0.26	0.17	-	-	0.09	0.06	29.70
Nagurtswadi Tamil Nadu	3.27	48.57	5.84	-	-	-	-	-	-	-	24.94
Dhangarwadi "	3.88	51.76	4.55	-	-	-	-	-	-	-	26.89
Udgiri "	2.50	49.63	4.63	-	-	-	-	-	-	-	-

RESERVES
(as on 1.1.1985)

(In '000 tonnes)

1.	Andhra Pradesh	2278
2.	Bihar	179
3.	Karnataka	7415
4.	Kerala	8731
5.	Madhya Pradesh	5849
6.	Maharashtra	7233
7.	Orissa	65
8.	Rajasthan	30352
9.	Tamil Nadu	12664
10.	Uttar Pradesh	13428
	Total - All India	75571

CONSUMPTION

(In tonnes)

	1986	1987	1988
Ceramic	2726 (12)	3068 (16)	3017 (16)

NB : Figure given in brackets indicates number of units

FELDSPAR

Feldspar is a common flux and is used in various types of ceramic bodies, the fluxing action depending on the amount and type of alkalies present.

Potash feldspar is preferred in ceramic bodies because of its long firing range, whereas soda feldspar is preferred in glazes because it reduces the viscocity of the melt.

The amount of feldspar used in ceramic bodies are as under :

Sanitary ware	25 to 35%
Electrical porcelain	30 to 45%
Floor & wall tile	10 to 35%

Specification IS : 9749 - 1981

		Whiteware	Other than whiteware
A)	**Physical** grain size	As agreed between supplier & purchaser.	As agreed between supplier & purchaser
	Sp. Gr.	2.5 to 2.7	2.5 to 2.7
B)	**Chemical %**		
	SiO_2	68.0	68.0
	Al_2O_3	17 -21	17 -21
	Fe_2O_3	0.35	0.50
	CaO/MgO	1.0	1.0
	K_2O	9.9	7.7
	Na2O	4	6
	Total Alkali	13	10
	SiO_2 - Al_2O_3	3.4 - 3.6	3.5 - 3.6
	L.O.I.	0.6	0.8
	Fusibility	Between cone 8 & 10 (1225 - 1260°C)	Between cone 5 to 10 (1180 - 1260°C)

CHEMICAL ANALYSIS

Source	Hamirpur (U.P.)	Jhansi (U.P.)	Gorumohisani (Orissa)	M.P.
		Constituents (%)		
SiO_2	54.48	64.98	77.66	60.28
Al_2O_3	32.41	27.21	15.38	29.83
Fe_2O_3	1.00	0.37	0.39	0.51
TiO_2	0.71	0.98	0.17	1.46
CaO	0.41	0.13	0.45	0.57
MgO	0.10	0.10	Tr	0.92
K_2O	0.33	0.13	0.56	0.08
Na_2O	5.36	0.37	2.85	0.44
L.O.I.	5.40	5.55	2.77	6.03

RESERVES

	1.28	million tonnes - M.P.
	3.05	million tonnes - U.P.
Total	4.33	All India

PRODUCTION

(Quanitity in tonnes)

Sr. No.	Source	1986	1987	1988	1989
1.	Madhya Pradesh	24761	30808	28542	46851
2.	Maharashtra	991	2089	724	1725
3.	Orissa	7298	11435	16701	21172
4.	Rajasthan	7290	8291	9712	11767
5.	Uttar-Pradesh	18544	7864	8491	12749
	Total - All India	58884	60457	64170	94264

CONSUMPTION

(In tonnes)

		1986	1987	1988
1.	Ceramic	603 (2)	1063(3)	1173(3)
2.	Refractory	757(11)	1114(11)	755(10)

NB : Figure given in brackets indicates number of units.

RESERVES
(as on 1985)

(In tonnes)

1.	Andhra Pradesh	902,200
2.	Bihar	1,725
3.	Karnataka	126,655
4.	Madhya Pradesh	19,372
5.	Maharashtra	943,871
6.	Meghalaya	43.424
7.	Rajathan	10,129,275
8.	Tamil Nadu	1,909,320
9.	Uttar Pradesh	100,000
10.	West Bengal	860,000
	Total - All India	15.034,842

PRODUCTION

(Quantity in tonnes)

State	1986	1987	1988	1989	1990
Andhra Pradesh	6926	5446	11374	5723	19360
Bihar	1050	2001	2141	3002	1694
Gujarat	9	2	2	0	1
Haryana	159	224	38	13	0
Madhya Pradesh	1001	2427	2807	443	670
Rajasthan	33377	40522	33307	35173	30114
Tamil Nadu	5742	6141	7987	5157	2296
Total - All India	48264	56763	57656	54135	59511

CONSUMPTION

(In tonnes)

	1986	1987	1988
Abrasive	180(4)	312(4)	371(4)
Ceramic	33346(44)	41191(42)	34465(42)
Refractory	5337(11)	7338(12)	81131(12)

NB : Figure given in brackets indicates number of units.

PRODUCTION

(In tonnes)

Sr. No.	Source	1986	1987	1988	1989
1.	Andhra Pradesh	10185	8875	13153	21471
2.	Bihar	145913	137601	114784	75015
3.	Gujarat	146503	143734	113439	120607
4.	Karnataka	13553	9957	7570	8498
5.	Madhya Pradesh	125734	91165	79156	78168
6.	Maharashtra	7493	8517	6875	6151
7.	Meghalaya	139	1210	850	-
8.	Orissa	123649	91936	91287	79882
9.	Rajasthan	44030	60209	62919	93265
10.	Tamil Nadu	51818	57253	66005	61969
11.	West Bengal	14420	27919	55533	67352
	Total All India	683437	638376	611571	612378

CONSUMPTION

(In tonnes)

	1986	1987	1988
Ceramic	67162 (32)	67308(30)	65871(28)
Refractory	433209(42)	373501(47)	393776(47)

NB : Figure given in brackets indicates number of units.

v)	Atterberg's No. (Min.)	20	15	10
vi)	Linear shrinkage (dry) percent max.	10	10	10
vii)	Maturity on firing 1350°C Max.	3	5	9
viii)	Modulus of rupture MPa ** Min.	3.5	3.5	3.5
Chemical requirements :				
i)	Loss on ignition percent by mass, Min.	10.5	9.5	9.0
ii)	Iron oxide (as Fe_2O_3) percent by mass, Max.	1.50	2.0	2.0
iii)	Titania (as TiO_2) percent by mass, Max.	1.50	2.00	2.0
iv)	Iron oxide and Titania combined (as $Fe_2O_3+TiO_2$) percent by mass, Max.	2.75	4.00	3.75
v)	Alumina (as Al_2O_3) percent by mass, Min.	30	25	20

* Values for this type of clay are given for material passing through 75 microns IS Sieve

** 1 MPa = 10.2 Kgf/cm^2

	1	2	3	4	5	6	7	8	9	10	11
IV.	**North Eastern Region**										
	Darrangiri-I	44.32	36.48	0.67	1.15	0.23	Tr	0.16	0.13	16.76	34-35
	Darrangiri-II	51-58	31.52	1.05	1.50	0.30	0.72	0.14	0.05	13.25	35
	Darrangiri-III	62.55	23.92	1.33	1.42	0.15	0.33	0.08	0.05	10.21	31
	Garo hills (Non-plastic)	44.65	35.45	0.92	3.27	-	-	0.22	-	14.65	33
	Jaintia hills (Non-plastic)	45.00	37.24	2.26	Tr	-	-	-	-	13.70	33
	Tura (Non-plastic)	44.65	36.32	0.92	3.75	0.65	Tr	0.22	-	14.65	33
V.	**Gujarat**										
	Vinaygadh-Rajkot	57.80	26.21	0.84	1.55	0.55	Tr	0.34	0.24	11.84	-
	Himatnagar Sabarkantha	56.55	28.21	2.04	1.55	0.55	Tr	1.56	0.32	8.11	-
	Muli Surendranagar	61.05	24.22	0.91	0.77	1.00	Tr	0.68	0.24	9.70	-
VI.	**Rajasthan**										
	Rajasthan	56.98	28.16	2.40	0.80	0.56	0.40	0.84	0.67	9.20	
		59.68	25.66	1.17	-	-	-	-	0.36	9.98	

RESERVES
(Kaolin, Ballclay & Other clays) as on 1.1.1985

(Quantity in '000 tonnes)

1.	Andhra Pradesh	23,584
2.	Assam	3,698
3.	Bihar	41,786
4.	Delhi	5,648
5.	Goa	15
6.	Gujarat	3,784
7.	Haryana	509
8.	Jammu & Kashmir	19,641
9.	Karnataka	10,943
10.	Kerala	89,398
11.	Madhya Pradesh	17,951
12.	Maharashtra	3,258
13.	Meghalaya	57,086
14.	Orissa	93,803
15.	Pondichery	2,352
16.	Rajasthan	208,072
17.	Tamil Nadu	46,218
18.	Tripura	91
19.	Uttar Pradesh	12
20.	West Bengal	249,725
	Total - All India	871,574

PRODUCTION

(In tonnes)

Sr. No.	1986	1987	1988	1989	
1.	Andhra Pradesh	89744	86285	135534	107291
2.	Gujarat	25581	10088	8146	1694
3.	Kerala	739	658	650	-
4.	Rajasthan	163498	180877	175857	141943
5.	Tamil Nadu	-	2004	149	879
	Total - All India	279562	279912	320336	251807

CONSUMPTION

	1986	1987	1988
Ceramic	109454 (29)	116335 (30)	117034 (31)
Refractory	7911 (16)	6913 (15)	6912 (17)

NB : Figure given in brackets indicates number of units.

RESERVES
(as on 1.1.1985)

(In '000 tonnes)

1.	Andhra Pradesh	13,648,631
2.	Arunachal Pradesh	108,529
3.	Assam	731,792
4.	Bihar	572,900
5.	Goa, Daman & Diu	90,069
6.	Gujarat	8,109,557
7.	Haryana	245,247
8.	Himachal Pradesh	2,417,552
9.	Jammu & Kashmir	762,536
10.	Karnataka	16,858,359
11.	Kerala	63,866
12.	Madhya Pradesh	8,011,420
13.	Maharashtra	3,455,572
14.	Manipur East	6,657
15.	Meghalaya	4,268,196
16.	Nagaland	308,948
17.	Orissa	1,017,282
18.	Pondichery	9,440
19.	Punjab	25
20.	Rajasthan	6,578,462
21.	Tamil Nadu	541,146
22.	Tripura	80
23.	Uttar Pradesh	1,520,430
24.	West Bengal	27,064
	Total - All India	69,353,760

BENTONITE

Bentonite is naturally occuring plastic clay of great commercial importance. And it falls mainly under montmorillonite group. It is characterised by possession of exchangeable ions.

In various bodies bentonite is used in small percentage chiefly for enhancing plastic properly. In pressed insulators presence of bentonite helps in retaining the sharp contours after release from the mould. In enamel slips bentonite is used to keep the frit ingredients in suspension.

Specification

IS : 6186 - 1986

Sr.No.	Characteristic	Requirement for		
		Type-I	Type-II	
			High grade	Off grade
1	2	3	4	5
1.	Moisture, percent by mass	5.0-12.0	12.0 max. 12.0 max.	
2.	pH	9.0-10.5	-	-
3.	Gel formation index	To pass test	To pass test	To pass test
4.	Swelling power fineness	-do-	-	-
5.	(a) Dry			
	To pass through 150 micron IS Sieve, percent by mass, Min.	-	98	98
	To pass through 75 micron IS sieve, percent by mass, min.	95	90	-
	(b) Wet			
	Retained on 150 microns IS sieve, percent by mass Max.	0.01	-	-
	To pass through 45 microns IS sieve percent by mass, Min.	90	98	-
6.	Viscosity at 30, centipoise Min.			
	a) Apparent	-	15	-
	b) Plastic	-	6	-
7.	Filtration loss ml. Min.	-	15	15
8.	Sand stontent percent by mass, Max.	-	2	2

Type-I - for Chemical industries, decolouring of petroleum and vegetable oil and Rubber industries.

Type-II - for Oil well drilling.

CHEMICAL ANALYSIS

									Constituents (%)	
Source	Si02	A1203	Fe203	Ti02	Ca0	Mg0	K20	Na20	S03	L0I
Bihar	48.77	27.74	4.55	1.59	2.15	2.32	0.32	0.20	0.32	12.44
Rajula, Gujarat	65.09	14.74	3.69	0.17	2.30	2.64	1.34	2.10	0.04	7.62
Akli, Rajasthan	54.46	18.74	9.58	2.86	0.33	2.26	1.06	2.73	0.48	8.02
Hathi-ki-Dhani, Rajasthan	49.19	19.52	10.23	2.66	2.52	1.63	0.95	2.35	0.30	10.61
Jaipur, Rajasthan	51.21	21.01	3.52	0.27	4.90	3.49	6.06	0.14	0.35	9.83
Karauli, Rajasthan	52.66	24.56	4.01	0.48	0.87	3.58	6.80	0.20	0.26	7.06
Jammu & Kashmir	57.29	19.04	1.32	0.21	2.73	4.59	0.44	0.25	-	13.98
Amreli, Gujarat	45.00	26.35	1.40	1.20	8.14	2.49	0.46	0.84	-	12.68
Amreli, Gujarat	46.76	26.00	0.60	1.20	11.92	2.18	0.84	0.78	-	9.70

1	2	3	4	5	6	7	8	9	10
8.	Dry Shrinkage (%)	15.0	14.0	19.2	20.00	25.2	22.4	15.2	15.2
9.	Plasticity by hand feel	Good	Good	Low	Low (Sticky)	Low to moderate	Low	Low	Low
10.	Water of plasticity(%) on dry basis	52.15	47.18	73.0	67.2	74.9	62.7	46.0	44.6
11.	Soapy Nature	-	-	Soapy to touch	Slighly soapy to touch	Extremely soapy to touch	Soapy to touch	Faintly soapy feel.	Faintly soapy feel.
12.	pH of 1:5 suspension	9.15	7.8	9.40	7.54	10.7	8.0	8.28	8.02
13.	Specific conductivity of 1:5 suspension (MnO. cm^{-1})	-	-	1.08×10^{-3}	8.51×10^{-4}	4.99×10^{-3}	6.4×10^{-3}	4.07×10^{-4}	3.5×10^{-4}
14.	Soluble salts calculated from sp. conductivity (%)	-	-	0.41	0.42	1.87	2.40	0.15	0.13

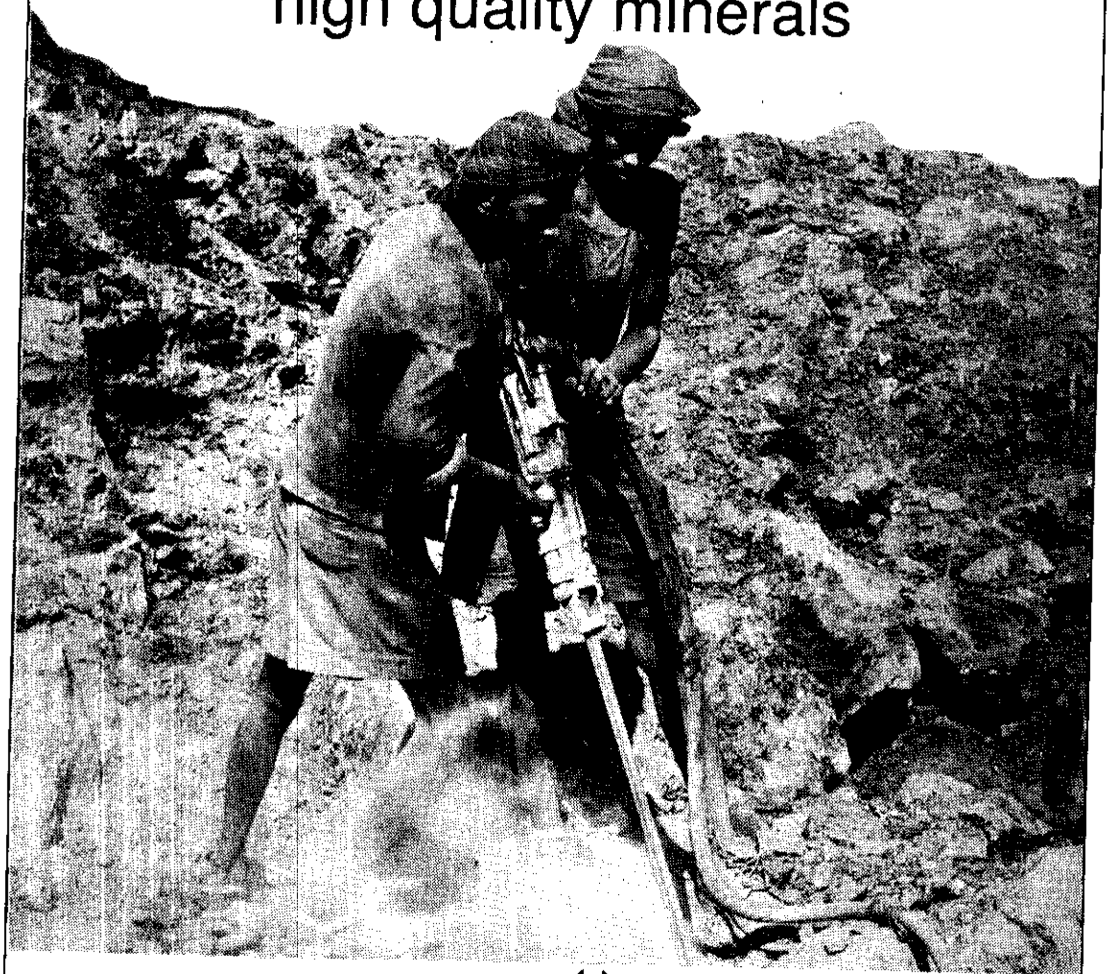
CHEMICAL ANALYSIS

	Constituents (%)									
Source	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	LOI	F.M.
Rajasthan										
Jaipur	62.30	1.33	0.,81	-	0.31	30.21	-	-	-	4.70
Udaipur	60.43	0.81	0.97	-	1.43	30.37	-	-	-	4.82
Madhya Pradesh										
Katni	59.21	0.95	0.51	-	1.62	29.72	-	-	-	4.82
Bihar										
Chaibasa	57.65	3.58	3.91	-	2.06	27.24	-	-	-	3.66
Uttar Pradesh										
Almora	63.11	0.30	1.03	-	3.01	27.00	-	-	-	5.04

PRODUCTION

(Quantity in tonnes)

State	1986	1987	1988	1989
Andhra Pradesh	11462	10874	17646	16140
Bihar	2305	2899	5743	1911
Karnataka	2430	2260	1980	1760
Madhya Pradesh	3238	390	1081	2542
Orissa	809	424	2056	1995
Rajasthan	326196	333567	357382	377951
Tamil Nadu	16519	10600	14100	6889
Uttar Pradesh	15303	15919	16357	19664
Total - All India	378683	377731	417493	429469



PYROPHYLLITE

Pyrophyllite is a secondary mineral of composition Al_2O_3, 4 SiO_2, H_2O. In appearance it looks like Talc and in physical properties it is identical to talc but in chemical composition it differs.

Pyrophyllite finds the same use as talc. It is used in refractory bricks and ceramic industries. It is used in tile bodies and in electrical insulator bodies.

The ISI has prescribed (IS: 11477-1985) following specifications for Pyrophyllite for Ceramic Industry :

***Specifications (IS: 11477-1985)**

Sr. No.	Characteristic	Requirement (%)	
		Grade-I	Grade-II
1.	Loss on ignition	6.0%(Max.)	6.0% (Max.)
2.	SiO_2	65% (Min.)	60% (Min.)
3.	Fe_2O_3 *	1.0% (Max.)	1.5% (Max.)
4.	Al_2O_3 *	23% (Min.)	25% (Min.)
5.	TiO_2	1.0% (Max.)	1.0% (Max.)
6.	CaO	0.5% (Max.)	1.5% (Max.)
7.	K_2O & Na_2O	0,5% (Max.)	1.5% (Max.)

Grade - I : Suitable for white ware and insulator industry.

Grade -II : Suitable for other ceramic industry.

* Sum of percent of iron oxide and titanium oxide for Grade-I and Grade-II shall not exceed 1.5 & 2 percent respectively.

DOLOMITE

Dolomite is a double carbonate of Ca & Mg. Dolomite is used in preparation of Glazes.

Specification

	Constitutents %				Physical characteristics
Grade-I for use in the L.D. converters.	MgO 21% (Min.)	SiO_2 1.0 (Max.)	Al_2O_3 1.0 (Max.)	Fe_2O_3 0.5 (Max.)	The mineral should be compact homogenous fine grained and non-decrepitation on calcination.
Grade-II for fetting purpose.	20% (Min.)	2.5 (Max.)	1.0 (Max.)	1.0 Max.	

CHEMICAL ANALYSIS

	Constituents (%)								
Source	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	LOI
Jalpaiguri (West Bengal)	1.76	0.48	0.76	-	29.63	21.07	-	-	46.41
Hyderabad (Andhra Pradesh)	2.42	0.90	0.80	-	30.40	20.79	-	-	44.52
Katni (M.P.)	3.60	0.86	0.49	-	30.06	20.20	0.50	-	40.60
Bhraduar (M.P.)	1.92	1.12	0.42	-	32.08	20.28	0.30	-	49.60
Jagda (M.P.)	2.64	0.82	0.94	-	30.18	21.24	0.30	-	44.08
Chivla (M.P.)	0.96	0.24	0.34	-	31.75	21.55	032	-	45.04
Birmitrapur (Orissa)	1.64	0.62	0.34	-	31.06	21.70	0.27	-	44.52
Panposh (Orissa)	1.64	0.62	0.34	-	31.06	21.70	0.27	-	44.52
Bhadravati (Karnataka)	1.36	1.45	4.43	-	30.10	19.30	0.81	-	42.90
Kalipahar (Rajasthan)	9.35	1.02	-	-	29.05	18.64	-	-	41.40
Massoori (U.P.)	0.20	1.62	-	-	29.95	20.82	-	-	46.12
Riasi (Kashmir)	3.62	1.03	1.71	-	29.57	19..82	-	-	44.48
Vadodara (Gujarat)	0.93	0.12	0.08	-	30.86	21.61	0.06	0.08	46.17
Vadodara (Gujarat)	1.52	0.36	0.32	0.03	31.02	21.14	0.05	0.08	45.22
Rajkot (Gujarat)	6.73	0.07	1.74	0.08	27.92	19.33	-	0.18	42.55
Bhavnagar (Gujarat)	9.72	2.08	0.99	0.08	29.83	15.84	0.05	0.25	41.12

FIRE-CLAY

The name fire-clay is given to a group of refractory clays which can stand temperature above PCE 18. Fireclay is generally sedimentary in origin and is usually found in Coal measures as bedded deposits. Fire-clay usually contains SiO_2, Al_2O_3, fe_2O_3 TiO_2, CaO, MgO and alkalies.

Depending upon the PCE values fireclays are used in manufacturing low duty, intermediate duty, high duty and super duty fire bricks.

Specification :

	Grade-I	Grade-2	Grade-3	Grade-4
Non-plastic/ Semi-plastic clay :				
Al_2O_3	35-40%	32-35%	30-32%	-
Fe_2O_3	1.0% (Max.)	1.0-1.5%	1.5-2.0%	-
PCE (Orton)	33.0 (Min.)	32.0 (Min.)	30 (Min.)	-
Plastic-clay				
Al_2O_3	30-32%	28-30%	22-28%	18-20%
Fe_2O_3	1-1.50%	2-3%	1-2%	1./5-2.0%
PCE (Orton)	30 (Min.)	28 (Min.)	26 (MIn.)	18-21

RESERVES
as on 1.1.1985 **(Quantity in ' 000 tonnes)**

1.	Andhra Pradesh	11645
2.	Arunachal Pradesh	2726
3.	Assam	3480
4.	Bihar	47815
5.	Delhi	61
6.	Gujarat	134521
7.	Karnataka	5458
8.	Kerala	7797
9.	Madhya Pradesh	102907
10.	Maharashtra	5438
11.	Meghalaya	8274
12.	Rajasthan	17811
13.	Tamil Nadu	90307
14.	Tripura	2248
15.	Uttar Pradesh	2700
16.	West Bengal	4555
	Total - All India	703087

PASMIN

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CHEMICAL ANALYSIS

Source		Constituents (%)									
		SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	LOI	PCE
	1	2	3	4	5	6	7	8	9	10	11
I.	**West Bengal**										
i)	Plastic	58.07	28.55	1.36	0.72	0.31	0.82	0.39	0.52	7.30	-
ii)	Semi plastic	50.96	36.54	1.00	1.76	0.24	0.19	0.79	0.34	8.70	-
iii)	Non-plastic	62.57	22.42	1.69	1.17	0.91	0.96	1.76	0.74	5.80	-
II.	**Orissa**										
i)	Belpahar (Non-plastic)	51.20	32.86	1.43	1.63	-	-	-	-	12.12	32
ii)	Belpahar (whitish) (Non-plastic)	47.32	35.07	1.71	2.42	-	-	-	-	13. 26	33-34
iii)	Belpahar soft grey (Plastic)	57.70	28.10	1.84	1.57	-	-	-	-	11.36	30
iv)	Talbasta-I	64-69	20-24	0.7-0.9	1-1.2 -	-	-	7-8	-		
	Talbasta-IV	47-57	29-36	0.7-1.8	0.7-0.56	-	-	-	-	11-13	
III.	**Kerala**										
	Thanakkal	43.56	39.37	1.10	0.46	0.065	0.06	0.37	-	14.70	-
	Chilambu-A	42.12	43.03	0.81	0.49	-	-	-	-	13.58	Above 35
	Chilambu-B	45.66	37.75	0.52	0.67	0.14	0.10	0.01	0.07	14.90	-
	Pallipuram-A	44.34	36.51	0.76	0.72	-	-	-	0.52	14.56	-
	Pallipuram-C	46.22	37.80	0.45	0.56	-	-	-	0.67	14.29	-
	Pallipuram-D	46.25	37.61	0.41	0.62	-	-	-	0.64	14.21	-

Loss on ignition varies between 14.50 to 18.73. This indicates that clay contains carbonaceous matter.

Table - 1

CHEMICAL ANALYSIS

	D/163	D/164	D/165
Si02	40.30	42.33	37.60
R203	42.15	41.35	41.85
Fe203	3..60	2.44	5.88
A1203	33.45	35.35	29.16
Ti02	5.02	3.56	7.61
Ca0	0.79	0.87	0.72
Mg0	0.09	0.07	0.06
P205	0.02	0.01	0.02
S03	0.10	0.15	Ab
Na20	0.30	0.40	0.40
K20	0.03	0.03	0.03
Mno	0.02	0.01	0.02
LOI	16.90	14.50	18.73
TOTAL	100.03	99.70	99.39

The combined Fe203 & Ti02 content in raw samples varies from 6.00% to 12.69. If these clays are washed properly and if Fe203 + Ti02 content can be brought down to 4.0 then it will fulfill the requirement for grade 2 laid down for plastic clay in IS 4589179.

II. PHYSICAL PROPERTIES :

Physical properties such as colour, plasticity by hand feel, % of water of plasticity, % of Dry linear shrinkage, Fired properties at 900°C, 1250°C and 1400°C are carried out, and the results are given in table No. II.

TABLE : II

Raw & fired properties

Ref. No.	D/163	D/164	D/165
A 1. Colour	Light Quaker grey	Light French	Light Vice brown
2. Plasticity by handfeel	Fair	Fair	Fair
3. % Water of Plascitiy	42.01	38.52	44.81
4. % Dry linear shrinkage	7.0	5.0	8.0
B. Fired properties at 900°C :			
1. Firing colour & Visual exam.	Near biege some cracks are visible but no speacks are visible.	Light beige colour some cracks are visible no specks are visible.	Near beige colour some cracks are visible and no specks are visible.

LIMESTONE

Limestone occurs almost in every part of the country. Limestone/whiting is usually used in glazes.

Specification :

Characteristic	**Requirements (On dry basis) %**
Silica as $Si0_2$ (Max.)	2.0
Fe_20_3 (Max.)	0.3
$CaC0_3$	Not less than 97%
Sulfur	0.10

CHEMICAL ANALYSIS

		Constituents (%)								
	Source	$Si0_2$	Al_20_3	Fe_20_3	$Ti0_2$	$Ca0$	$Mg0$	K_20	Na_20	L0I
I.	**Andhra Pradesh**									
	Palkur	1.09	0.23	0.07	-	55.40	0.48	-	-	43.05
II.	**Assam**									
	Mikir hills	7.40	3.31	3.19	-	45.64	0.90	-	-	38.75
II.	**Bihar**									
	Japla	0.54	0.15	0.33	-	54.20	0.15	-	-	40.74
III.	**Orissa**									
	Bisra	5.48	1.64	1.68	0.18	44.50	6.48	-	-	38.70
IV.	**Rajasthan**									
	Sojat	-	0.12	0.03	-	55.30	0.15	-	-	43.40
V.	**Tamil Nadu**	0.92	0.34	0.12	Tr	53.46	1.16	-	-	42.92
VI.	**Gujarat**									
	Amreli	2.27	0.88	0.88	0.08	53.05	0.41	0.14	0.15	42.17
	Jamnagar	0.95	0.97	0.42	0.08	53.46	0.16	0.16	0.40	43.36
	Junagadh	3.89	0.79	0.94	0.08	52.09	0.47	0.18	0.13	41.05
	Kachchh	3.25	0.66	1.86	Ab	52.52	0.10	0.08	0.10	41.22

III. PARTICLE SIZE ANALYSIS :

The particle size of clays is an important charteristic since it is directly related to the plasticity and drying shrinkage. The specific surface area of any particular clay varies with particle size distribution, particle shape and the presence of cracks and pores in the sample. Particle size analysis of three samples are carried out by sedimentation technique. The data obtained are as under :

TABLE : III

Particle size Analysis by Sedimentation Balance (Sartoriu Germany)

Particle size in micron	D/163	D/164	D/165
45	4.00	1.30	1.90
40-45	0.20	0.20	0.20
30-40	0.20	0.40	0.00
25-30	0.10	0.50	0.10
20-25	0.30	0.80	0.10
15-20	0.60	1.20	0.20
10-15	0.90	1.70	0.40
8-10	0.40	1.00	0.40
5-00	1.20	2.10	0.90
3-5	1.60	1.90	1.20
2-3	1.60	1.40	1.30
2	88.90	87.50	93.30

These samples were sent to C.G.C.Ṙ.I. Naroda to carry out particle size analysis upto 0.5 microns. The particle size distribution by Andreasen's pipette method is done by them and the data obtained area as under :

TABLE - IV

Particle size analysis By Anderson pipette method

Particle size in microns	D/163	D/164	D/165
25	2.40	2.60	8.4
15-25	1.60	1.80	1.60
10-15	3.20	2.00	1.60
8-10	2.00	1.60	1.20
5-8	4.00	4.40	3.60
3-5	4.40	5.20	4.40
2-3	4.00	4.00	3.60
1-2	6.00	4.40	7.60
0.5-1	28.00	12.00	10.00
0.5	44.00	62.00	58.00

The particle size distribution shows that more than 87% is finer than 2 microns by sedimentations technique and By Anderson pipette it comes to more than 75%.

PRODUCTION

(In tonnes)

State	1986	1987	1988	1989	1990
Andhra Pradesh	8225	7897	9170	9470	11425
Assam	220	210	201	219	247
Bihar	1785	1750	1847	1812	1345
Gujarat	5070	6516	5658	6492	7541
Haryana	498	467	515	538	580
Himachal Pradesh	1168	1127	1169	1275	1393
Jammu & Kashmir	143	146	175	182	119
Karnataka	4315	4495	5384	5251	5140
Kerala	266	300	269	363	381
Madhya Pradesh	13430	15246	16569	17338	17693
Maharashtra	1979	3163	4456	4835	5068
Meghalaya	255	242	234	240	267
Orissa	2953	2816	2577	2263	2137
Rajasthan	6087	6287	6840	7345	7087
Tamil Nadu	5336	5020	5448	5277	5632
Uttar Pradesh	1829	2156	2485	1131	845
West Bengal	2	-	1	1	1
All India	53557	57838	62998	64032	66931

CONSUMPTION

(In tonnes)

	1986	1987	1988
Ceramic with other Industries	37871 (53)	38419 (59)	40325 (53)

NB : Figure given in brackets indicates number of units.

RECOMMENDATIONS

The complete physico chemical and mineralogical studies of this clay was conducted in our laboratory keeping in view of utilizing it in ceramic industries. Systematic studies by substituting Rajpardi clay in place of Bikaner clay in stoneware bodies were also conducted by C.G.C.R.I. Center, Naroda.

Workability of the body made from Rajpardi clay is found quite satisfactory in the items like crockerywares, sanitarywares and wall tiles. Since it contains somewhat more Fe203, it is not suitable for insulators. From the studies, it was revealed that 75% Rajpardi and 25% Bikaner body has given very satisfactory results with high fired M.O.R. and less rejection.

Rajpardi clay is promising kaolinitic clay. It contains higher proportion of less than 2 micron material. If clay is washed properly and blended with proper clay. Probably it can replace Bikaner clays. Hence it is recommended that serious efforts in this direction is necessary. Since the clay occurs as over burden and over burden hasgot commercial utility hence serious efforts are necessary for upgrading the clay.

CERAMIC RAW MATERIALS FOR WIHTEWARE INDUSTRY

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INTRODUCTION

Over the years, Whiteware Ceramic and allied industries of our country have witnessed great changes, both in quality and quantity of products manufactured, and today these industries play a vital role in in the country's industrial and socio- economic progress. The demand for whitewares have also increased in many folds due to accelerated activities in the fields of power generation and transmission, rural electrification, building construction and for house-hold applications. Quality of production has also improved greatly and it is creditable that our dependence of imports for whiteware ceramic products has come down enormously and we are today exporting ceramic goods valued at several crores to not only our neighbours, but also to some of the advanced countries.

The whiteware ceramic products of industrial importance and manufactured in both the organised and unorganised sectors of our ceramic industry include Soft Porcelains for art & tableware; High Tension (HT) Insulators; Glazed wall & floor tiles; Vitreous Sanitaryware, Semi-vitreous Tableware; Dental Porcelain; Crockery and others.

Whiteware Ceramics are almost non-porous, white and partially translucent ceramic material. A wide range of compositions is possible from the system K20-A1203-Si02 which finds various applications as said earlier in modern technology. The conventional composition of Whiteware Ceramics comprises three major components : Clay (China clay & Ball clay), Quartz & Potash Feldspar. The ratio of the components in the raw material mix varies according to the desired properties of the ceramic products.

In the various whiteware compositions the clays serve a dual purpose of :

(i) providing fine particles and good plasticity for fabrication of articles.

(ii) forming fine pores in the articles and less viscous liquid essential to the firing process as well as producing acicular mullite crystallites in the fired products.

Both china and ball clays are used in the whiteware compositions. China clays have relatively large particles, medium plasticity and drying shrinkage, poor dry strength, and is white burning. Ball/plastic clays have fine particles, high plasticity and drying shrinkage, high green strength and contain large amount of impurities which make the body buff burning, low maturing and less translucent. Hence, a balance is struck by using a minimum amount of ball clay which is essentially required to develop plasticity and dry strength, the remaining part being white buring but non-plastic China clay. The potash feldspar acts as flux, forming a viscous liquid at the firing temperature, and aids in vitrification. Silica in the form of quartz is another important constituent in a whiteware composition. It is mainly an inexpensive filler material which during firing remains unreactive at low temperature and at high temperature forms a high viscosity liquid.

requirements of the users. As a result they produce processed clays which are inconsistent and the quality varies from lot to lot. The pottery/whiteware industry on the other hand suffers and the quality of products deteriorates. It is, therefore, needless to emphasise that the role of the suppliers is of major importance probably the more important than the role of research or the Scientist.

Hence, it is for the fitness of thing to review the status of major ceramic raw materials in the country and initiate remedial measures for the shortcomings existed.

REQUIREMENT OF RAWMATERIALS IN WHITEWARE INDUSTRY

Before we discuss the present status of major ceramic raw materials in the country it is essential to highlight in brief the requirement of the same for whiteware industry.

The raw materials of widest application are the clay minerals - fine particle hydrous aluminium silicates which develop plasticity when mixed with water. They vary over wide limits in chemical, mineralogical and physical characteristics from mine to mine and also in place to place in a single deposit.

In addition to the hydrous silicates anhydrous silica and silicate minerals as well as feldspars are basic raw materials for much of the ceramic industry. SiO_2 is a major ingredient in whiteware compositions. It is used as quartzite rock, as quartz sand as well as sand stone. Many of these non-plastic materials are heterogeneous and variable. However, a material of uniform, reliable and consistent quality is required for ceramic production. Hence, it is customary to find out the suitability before incorporating them into any ceramic body formulations.

China Clays (Kaolin)

The most common clay minerals and those of primary interest to ceramics, since they are the major component of high grade clays, are based on the kaolinite structure, $Al_2 (Si_2O_5) (OH)_4$.

Kaolinite based clays are mainly residual clays and are found in the same location as the parent rock from which they are derived. Hence, they are also called primary clays and fire to white or nearly white in colour.

Crude clays after washing should essentially consist of the mineral Kaolinite (Al_2O_3, $2SiO_2$, $2H_2O$) having a theoretical composition of 39.8% Al_2O_3, 46.3% SiO_2 & 13.9% H_2O.

ii) Ball/Plastic Clays

Ball/Plastic clays are secondary clays. These impart high strength and good workability to whiteware bodies. The primary mineral phase present in the clays is kaolinite. Micaceous minerals and quartz are the dominant minerals present as impurities along with minor amounts of felspar, chlorite, titania, haematite etc. In normal practice, ball clays are used in the range of 10 to 40% in various whiteware compositions.

most important drawback noticed is its powerful reducing effect on the oxides of iron and great care is necessary to burn off the carbon with sufficient air supply before the reduced iron can form a fused slag or back core.

Lime and magnesia compounds occur in clays are generally carbonates or sulfates. Lime compounds with alkalis in clays may produce a glassy phase at a relatively lower temperature. Again lime in combination with free silica forms several compounds and most of them have lower softening points than the clay itself. Carbonates in porous body remained as clacium oxide after firing, which slakes in water, evolves heat and causes expansion. Salts of magnesium renders harmful effects in clays.

Iron compounds are invariably present in all clays and other raw materials and lower the maturing point and also impair the colour of the fired products. The presence of iron compounds in clays is almost undersiable in the production of hard porcelain and bone chine wares. Iron contamination of clays may take place from various sources : (i) due to presence of various salts viz; iron oxides, sulphides etc. (ii) iron may be a chemical constituent of the mineral itself by replacement of aluminium in the crystal lattice, (iii) iron may got contaminated in clays during transportation, in grinding operations, in processing of the minerals through different equipments, Iron, if present as carbonates and sulphides decomposes to Fe0 with evolution of gases at 1000C. The gases are very detrimental to the fired products. The atmosphere of the kiln during such operation is also important.

Titania (Ti02) is present in clays and other materials as rutile (Ti02) or calcium titanite (CaTi03) and they act as powerful fluxes. Titania imparts a yellowish colour to the fired product and the colour deepens in the presence of iron compounds.

Soluble salts present in ceramic raw materials produce scum on the surface of the body during drying & firing. Certain soluble salts interfere during the preparation of casting slip and are the cause for consumption of excess electrolyte. The presence of soluble salts are also the cause of scumming and efflorescence. They tend to migrate to the surface with water in the shaped wares and water dried out leaving the salt on the surface. During firing, if the salts are not removed from the surface of green wares, these accumulated salts act as a local flux producing irregular wares. The salts present are generally calcium and magnesium sulfates, chlorides etc. followed by iron, potassium & sodium sulfates.

Preparation of bodies by the wet methods of blunging, mixing and filter pressing removes a lot of these undesirable soluble salts.

But if the raw materials are not treated by filter pressing, the best way to get rid off soluble salts in the raw materials by treatment with barium carbonate. Barium carbonate reacts with soluble sulfates to give insoluble barium sulfate and only slightly soluble carbonates.

BaCO3 + CaSO4 = BaSO4 + CaCO3

2.4 mg 201.6 mg 0.23 mg 1.3 mg

(soluble/100 ml. of water at 18°C)

Due to undesirable effects of the various impurities in the properties of whiteware products, these are required to be eliminated from the raw materials completely or brought down to certain level as mentioned in the respective Indian Standards to make the materials suitable for whiteware production. Apart form above, the impurities in raw materials are essential to control for the purpose of standardisation to ensure satisfactory as well as consistent production.

industry.

Hence, the need for judicious blending at this crucial movement is not over emphasised. It is more important now to control the quality of raw materials and then ensure a consistent regular supply to the industry.

Apart from that, time has also come to classify the various deposits with reference to clay requirements of different whiteware products and then reserve the sources accordingly. Low grade clays containing more colouring oxides (Fe203 & Ti02) should be increasingly used in earthenware and stoneware industries leaving good quality clays for use in sanitaryware, porcelain and bone china products as national policy.

Introduction of Improved Processing Techniques

Most of the china clay processing units except a few in the country employ levigation technique for beneficiation which is a simple and cost effective method. But the technique is not universally applicable to different types of crudes as the process had several limitations. Modern units with improved processing techniques are available with M/s. Kerala Ceramics Ltd., M/s. Neyveli Lignite Corpn., and M/s. English India China Clay Groups.

M/s. Kerala Ceramics had set up the clay processing unit with the technical collaboration from M/s. Oharu Mfg. Co. of Japan, incorporating all facilities for mining, blunging, bleaching, dewatering & drying. The crude is blunged in both vertical and horizontal blungers followed by a series of Rotary Screens and cyclons for beneficiation of the clay eliminating the under sized quantum of sand. The clay suspension is passed for further treatment in the form of oxidation and reduction bleaching by chlorination to improve brightness. Finally, the suspension is spray dried. HIMS techniques is not applied as the quality of the crude is good and even without this technique the processed clay meets the specification of Grade I china clay.

Technical Evaluation of Crude Clays is necessary in order to know the nature of the material and its influence in the ceramic processes and the products. In order to characterise the material, chemical analysis and the measurement of particle size distribution are important. These two informations regarding the material are sufficient to decide whether the material in question can be utilised without further processing, whether processing will be necessary and which sort of processing should be considered.

There are limited number of processing options. These are generally processes which rely upon Size Separation through simple Levigation Technique and or Hydrocycloning by a wet route, Magnetic Separation by HIMS, Froth Flotation and Chemical Treatments such as Acid Leaching and Bleaching. The process routes are illustrated in Fig. 4.1.

These processes are often used in combination with each other if the benefits so obtained are economic. The more complex the process routes the more expensive the product becomes.

Some of the improvements which result from the use of some of these techniques either singly or in combination are illustrated in Figures 4.2 & 4.3 as available from the literature.

The data as furnished in Fig. 4.3 helps to assess whether all the processing is needed to obtain a marketable product, and whether intermediate products are also suitable for certain whiteware products. Such data also helps to find out the economic viability of the product as well as to study the pay-back period for the project.

PRODUCTION

(In tonnes)

	1986	1987	1988	1989
Andhra Pradesh	7125	2536	468	18872
Bihar	166603	148276	186003	205426
Gujarat	232652	309103	307209	399547
Haryana	-	570	-	-
Karnataka	12613	8353	2235	1604
Madhya Pradesh	79221	650584	623923	547278
Maharashtra	29360	30942	25866	20314
Orissa	989019	967213	1034076	1088904
Rajasthan	9445	6481	4100	5072
Uttar Pradesh	107245	69274	19357	47724
West Bengal	76801	45575	18637	17684
Total - All India	2210084	2238907	221874	2352428

RESERVES
(as on 1.1.1985)

Total Reserved	4608	million tonnes
Proved	277	million tonnes
Probable	1063	million tonnes
Possible	3268	million tonnes

CONSUMPTION

(In tonnes)

	1986	1987	1988
Refractory	436741(4)	462351(4)	462641(4)
Ceramic with other industries	678(25)	338(28)	264(26)

NB : Figure given in brackets indicates number of units

The above example indicates how important and versatile the improved processing techniques are ? Earlier, these techniques are introduced in the Indian raw material industry, better is for the whiteware industry in our country.

4.3 Search for New Materials for Whiteware Industry

It is equally important for Indian whiteware industry to search for the introduction of new raw materials which are in abundant supply without keeping prolonged dependence on the conventional raw materials.

There have been some important developments taken place in this front in the foreign countries in the last few years. Wollastonite has been successfully introduced in Wall Tile Industry. On the other hand, New Zealand China Clays Ltd. had developed an unique material named Halloysit : despite considerable disadvantages with respect to processing difficulties and geographical location. The material has been introduced with considerable success for the production of porcelain and bone china tableware where the very low iron and titania contents and consequently excellent fired coloured have been the advantages of this material over conventional materials.

Indian Ceramic Researchers as well as the industry are alive to the situation and the progress made in this direction are :

Wollastonite in Whiteware Ceramic

Wollastonite is a mineral, mostly calcium meta-silicate having no water molecule in the structure and no crystallographic transformation in the firing range. Wollastonite reserves in Jodhpur division of Rajasthan State are estimated to be 25 million tonnes. Deposits in Tamilanadu and Madhya Pradesh have also been reported.

In India, Wollastonite in extensively used in wall tiles, building materials and in the manufacture of cold face insulating material. The fibrous morphology of the mineral stops laminations and helps easier pressing of ceramic bodies including wall tiles.

Extensive use of wollastonite in pottery bodies like, crockery and Sanitaryware is yet to take place in our country despite its promise in reducing drying and firing shrinkages, cracking, warpage, moisture expansion and dunting. However, its use in crockery and sanitaryware may be limited to 8 to 10% only due to shortened maturing range and buff firing colour at higher proportion.

Wollastonite being a source for Ca0 and Si02 can be used in Pottery Glazes with advantage for brighter, smoother and pinholes free brilliant glazes for Sanitaryware, tiles, sewer pipes, earthenware & porcelain enamel frits.

Its use in making of Ceramic Moulds has also been reported. The moulds have 7 to 8 times longer life and much greater abrasion resistance than the conventional plaster of paris moulds.

Hence, wollastonite appears to be an important materials which needs to be further exploited for the benefit of our whiteware industry.

Pyrophillites and Sericites in Whiteware

Pyrophillite is another important material which is yet to find its extensive ways in the Indian Whiteware Industry. It is used in refractories and wall tiles at present. It is an aluminosilicate material and is available in plenty in India. But utilisation of this material in triaxial whiteware

OCCURRENCE OF KAOLINITIC CALY AS OVER BURDEN OF LIGNITE AT RAJPARDI (BHARUCH DISTRICT)

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ABSTRACT

Seven clay samples were collected from different benches of Rajpardi working mines of lignite. Out of these : three clay samples from north bench are studied in details. The said clay samples are taken up for studying its physico chemical properties such as chemical analysis, physical properties, Particle size analysis, x-ray diffraction analysis. Differential thermal analysis.

During the study it is revealed that Rajpardi clay is promising body made from Rajpardi clay. (75% Rajpardi clay + 25% Bikaner clay) is suitable for manufacturing crockery ware, sanitary ware and wall tiles. Looking to the particle size of the clay it is advisable to wash the clay for better price and for making better ceramic product such as insulators etc.

The diagram showing the exact location of samples is shown below :

INTRODUCTION :

Sample No. D/163, D/164 & D/165 are studied in detail for knowing its probable industrial utility. The detailed laboratory study conducted is as under :

I. Chemical analysis

II. Physical properties

III. Particle size analysis

IV. X-ray diffraction study

V. Differential Thermal Analysis

Sr. No.	Ref No.	Details Location
1. D/163	Greyish White clay (A)	North bench
2. D/164	Greyish white clay (B)	"
3. D/165	Grey clay (C)	"

CHEMICAL ANALYSIS

Chemical analysis indicates that free Si02 content is less as Si02 varies from 37.60 to 42.33%. The Al203 content varies between 29.16 to 35. ,35. It indicates that clay content is comparatively good.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In conclusion, I would emphasise once again that the raw material suppliers cognizant of industries stringent need for consistent quality high grade material with regular supply at reasonable price continue to play a vital role in product development and in the improvement of productivity and product quality in the whiteware industry.

Hence, from the foregoing discussion it may be concluded that the future prospect of the Whiteware Industry in our country is bright with reference to the supply of principal ceramic raw materials provided appropriate action as discussed is taken in a specified time frame.

Recommendations

The priority areas where both the suppliers, user agencies and DGTD may take appropriate action have already been highlighted. The recommendations are furnished below.

(i) R&D programmes for an extensive survey and evaluation of clay resources in the country should be undertaken by appropriate authority in close collaboration with G.S.I., I.B.M., & other Govt. Agencies in view of the growing needs of the clay consuming industries.

(ii) Existing clay washing units be upgraded and new modern clay processing units set up employing Improved Processing Techniques with a view to supply consistent quality clays.

(iii) Classify the various deposits with reference to clay requirements of different whiteware products and then reserve the sources accordingly.

(iv) Search for new raw materials and R&D for their gainful introduction in whiteware compositions may be continued to lessen the prolonged dependence on the conventional raw materials.

(v) To set up Institute on Whitewares to exclusively deal with the problems and the future needs of Whiteware Industry.

(vi) To provide finance either from Government or from the industry to some of the existing National Laboratory for creating adequate infrastructural facilities both equipments & manpower to tackle industrial problems or one of the Laboratory may be equipped as Institute on Whitewares.

(vii) Some of the clay processing units may be selected based on the potentality of the clays for upgradation and help them in various ways namely, finance, foreign collaboration, technical expertise etc. to achieve excellence.

(viii) Deputation of scientist and Engineers from laboratory and industry for training in specialised line and then implement the findings for benefit.

(ix) Finally, offering financial benefits/incentives by the Government to the clay processing units opting for modern technology for raw material upgradation.

2. % Fired linear shrinkage	11.0	9.0	13.0
3. % water absorption	31.57	29.62	28.04
4. Vitrification	None	None	
C. Fired properties at 1250°C :			
1. Firing colour & visual exam.	Light straw colour. No cracks are visible. but many brown specks are visible.	Portland stone colour. No cracks or specks are visible but some pinholes are visibles.	Near sunshine colour. Many deep cracks visible, but no specks are visible.
2. % Fired linear shrinkage	23.0	23.0	22.5
3. % water absorption	1.88	1.46	* 1.12
4. Vitrification	Fair	Fair	High
D. Fired properties at 1400°C :			
1. Firing colour & visual exam.	Near middle buff colour some cracks and some specks are visible.	Near light stone colour Many deep cracks and some specks are visible.	-
2. % Fired linear shrinkage	20.0	22.0	-
3. % water absorption	* 3.27	* 1.82	
-			
4. Vitrification	High	High	-
E. Pyrometrtic Cone equivalent (PCE)	Between orton cone 32-32 1/2	Between orton cone 33-34 (close to 33)	Between orton cone 28-29
Temp. 0C	1717-1724 0C	1743-1763 0 C	1646-1659 0C

NB : * Water absorption data is high due to test pieces are cracked.

IV. X-RAY DIFFRACTION STUDY :

The x-ray diffractometer Philips with following setting was used :

Target	Copper	KV-30
Filter	Nickel	MA-20
Radiation	Cu K	Range - 400
Divergence Slit - i		
Chart speed 1mm/min.		
Scanning speed 2 0/min.		

From x-ray diffraction study it is observed that sample No. D/163, D/164 & D/165 contains kaolinite as main mineral and accessory mineral is Anatase.

V. DIFFERENTIAL THERMAL ANALYSIS

Perkin Elmer DTA 1700 with system 7/4 Thermal analysis controller high temperature DTA was used with following parameters.

Mesh Size :	(-) 200 B.S.
Temperature j:	Min. 350°C and Max. 1030°C.
Heating rate	10°C/Min
Purge gas :	Iolar-2 Nitrogen

Ref. No.	Endothermic peak	Exothermic peak	Conclusion
D/163	100°C small and shallow endothermic peak. 535°C main endothermic peak.	Broad exothermic peak observed at 945°C.	Sample contains disordered kaolinite
D/164	100°C small shallow endothermic peak. 530°C Main endothermic peak.	Sharp exothermic peak at 955°C.	Sample contains kaolinite.
D/165	100°C small shallow endothermic peak. 530°C main endothermic peak 570°C (Sh).	Sharp and small Exothermic peak at 935°C.	Sample contains disordered kaolinite and Quartz.

The chemical treatment to remove iron oxide impurities involves addition of a reducing agent to clay-water 3 + 2 + slurry where Fe (insoluble state) is reduced to Fe (soluble state) and remove. Some clays require treatment with an oxidising agent before treating with reducing agent. Pigment grade kaolins with brightness of 80 + 82% can be achieved from this series of steps.

Another major impurity contributing colo9ur to the clays is the anatase titanium dioxide. Although, commercial, pigment grade anatase is white with brightness nearly 100, where as the anatase impurity in clays is dark reddish brown. In addition, some titanium dioxide is also present in rutile form.

Amongst the methods known for removal of titanium dioxide impurities the important ones are :

a) Carrier mineral flotation.

b) Froth flotation.

c) Selective flocculation.

d) High gradient magnetic separation.

Carrier flotation make suse of a carrier mineral to collect the finely divided anatase. Calcite has been found to be a satisfactory carrier mineral due to its low cost, flotation response, availability and ease of removal from clay product organic polymers such as polypropylene and nylon are also claimed to be effective.

Although carrier flotation can increase the brightness of clay by about 4 units, there are additional problems. The flotation is carried out at fairly low solids and dewatering becomes difficult.

Froth flotation without carrier mineral has been attempted by several workers. Some of the processes developed work well for coarse kaolins and they are not successful in removing anatase impurity from the fine particle, higher value kaolins.

Selective flocculation involves careful control of the ionic environment in an aqueous suspension of clay where clay will be in a deflocculated state and allowing anatase impurities to flocculate.

High gradient magnetic separation makes use of the magnetic property of the materials for effective separation. This method is found to be effective in removing both iron oxide and anatase impurities. A typical magnetic separator as used with kaolin clay slurries consists of a canister packed with magnetisable steel wool. This canister is surrounded by an electromagnet capable of generating field strengths of 2 tesia. In operation, kaolin slurry is pumped through the energised magnet and the colouring impurities are retained on the magnet. The magnet is deengergised and the impurities are washed with the water pumped through the canister. New generation commercial superconducting magnetic separators are available and are found to be economic at higher throughputs.

Problems related to beneficiation of clays in the Indian context :

a) *Variability of clays :*

Clay from different deposits behave very differently in response to the beneficiation methods described above and hence the development of suitable technology is going to be deposit specific. This parameter, infact, is a major one affecting the beneficiation processes to be chosen.

Apart from above, the whiteware composition have to satisfy certain basic prerequisites before it can be put to large scale production. At the first instance, the body should be sufficiently plastic and amenable to extrusion, jiggering casting and pressing. Secondly, the dried body should have adequate mechanical strength for handling during subsequent production steps. The particle size and particle size distribution of the body mix should be adequate which strongly influences the forming and firing processes as well as enhances the dry strength of the body. For plastic forming the coherence and the yield point of the mass depends on the capillarity of the liquid between the particles which in turn is inversely proportional to the particle size. Intimate mixing of various constituents is also very important to ensure vitrification as well as to ensure development of a uniform mircrostructure without localised faults.

The main differences among different whiteware ceramic products are in the relative amounts and kinds of feldspar and clay used. With an increasing amount of feldspar in the composition, the amount of liquid formed at the eutectic temperature increases, vitrification proceeds at a lower temperature. Dental porcelains require high feldspar and low clay in the composition in order to produce higher translucency. In contrast, hard porcelain artware and tableware compositions require certain amount of feldspar replaced by clay for successful forming. Higher temperatures are required for vitrification, and the firing process becomes more difficult and expensive. However, the mechanical and electrical properties of the resulting body are improved. Similarly, for automatic forming machines, as those used for hotelwares and high tension insulators, larger amounts of ball clay are used. Compositions such as low-tension electrical porcelain are not critical as regards either forming or firing operations.

Before we discuss on whiteware raw materials in details, we must view in brief the interactions of different raw materials depending on their types and amount into the body mix as well as the development of microstructure occurred during firing. Firing is also related to the schedule of time and temperature and the reactions to be occurred at different stages apart from its dependence on the quality of raw materials. During firing of a whiteware body free water is removed in the initial stages (~200°C). As temperature increase, organic matter present in the clay material burns off between 200 to 700°C. At a temperature of about 573°C, all the quartz in the body inverts to the high temperature form accompanied by ~2% volume expansion. Between 500 - 600°C the clay structure breaks down. Dehydroxylation of the clay breaking to a disordered structure (meta-kaolin) and the structural water is released. The change is accompanied by a reduction in volume and a considerable increase in porosity of the body. At about 980°C, the amorphous structure of the clay rearranges itself, first into a spinal and then into extremely fine mullite (primary mullite) and amorphous silica which reacts readily with the feldspar grains present in the mix to form an an eutectic melt at around 1140°C. Very fine mullite begins to form in the clay components in the 1000-1200°C range. In presence of the liquid phase, sintering takes place and the final mircrostructure is developed.

In this context, if we compare the status of Whiteware Industry in India with that of the developed country we find that our technology and our industry as a whole are lagged behind. The condition of industry in the small scale sector, which constitutes about 85% of the total whiteware industries in our country, is still worse. Many industrial experts believe that one of the major causes to this big technological gap is the constraints in the availability of standard and consistent quality principal ceramic raw materials.

Most of the clay processing units in our country process the clay in a very crude manner having inadequate control over quality. Sometimes, they are found quite ignorant about the

HI-TECH BENEFICIATION OF CHINA CLAYS

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Abstract

China clays are always found to be associated with inherent impurities such as quartz, laterite, mica, iron oxides, titania, etc., which influence their plasticity, colour and fired properties. Different methods both conventional and hi-tech are reported to have been successfully adopted for beneficiation of china clays. Conventional method includes washing of the crude clay by sedimentation technique or dry process of air floatation after certain pre-processing of the crude clay. Hi-tech method includes beneficiation of the above processed clay by hydrocyclone separator, ultra froth floatation, high intensity wet magnetic separator for removal of magnetic, feebly magnetic and paramagnetic substances and finally by chemical decolourisation. Results of experiments carried out by this Institute have been incorporated. It has been shown that the light reflectance of the clays which are otherwise suitable but for their low reflectance values are unsuitable for paper and textile industries could be substantially improved so as to make them suitable for paper and textile industry if hi-tech process of beneficiation is applied.

iii) Quartz

SiO_2 in quartz mineral is a major ingredient in whiteware compositions. It is widely used because it is inexpensive, hard, chemically stable, and relatively infusible and has the ability to form glasses. There is a variety of mineral forms in which silica occurs, but by far the most important as raw material is quartz. Another major source of silica is sand stone which consists of lightly bonded quartz grains. Sand stone is widely available in Gujarat.

iv) Feldspar

Feldspar an anhydrous aluminosilicate containing K^+, Na^+, or Ca^{2+} as a flux which aids in the formation of a glass phase. The major materials of commercial interest are potash feldspar (Microline or Orthoclase) K_2O Al_2O_3 6 SiO_2(albite), Na_2O, Al_2O_3, $6SiO_2$; and lime feldspar, (anorthite), CaO, Al_2O_3, $2SiO_2$.

Effects of Impurities in Raw Materials on whiteware products

The major impurities in the ceramic raw materials as seen from the above elaboration are :

i) Silica in clays either in free state or combined state
ii) Alkalis present either as soluble salts or insoluble compounds.
iii) Organic matter
iv) Lime and magnesia either as carbonates or sulfates
v) Iron compounds
vi) Titanium
vii) Various other soluble salts etc.

The amount of impurities in the raw materials if exceeds the limits as specified in the respective standards, these causes adverse effects on the properties of whitewares. The effects of impurities on whiteware products are narrated in brief.

The effect of presence of free silica/free quartz in clays are reduced plasticity, reduced shrinkage, tendency to warp, tendency to crack at the inversion temperature of quartz, reduced tensile and compressive strengths, increased porosity and reduced thermal shock resistance of the clay body.

The effect of alkalis present in clays and other raw materials except feldspar may be summed up as : (1) to increase the fusibility, (ii) to produce a scum on the surface of the body either on drying or on firing. The most usual form of alkalis present in clays are the alkali-aluminosilicates such as feldspar, mica etc. The common form of mica present is muscovite or potash mica.

Organic impurities when present in clays should not exceed about 5% as otherwise the clay is seldom workable. The changes noticed due to presence of carbonaceous matter in clays are (i) its colour before & after firing, (ii) increased plasticity due to humus, (iii) increased porosity after firing, (iv) increased amount of water absorption in green state and increased percentage of firing shrinkage. The advantage noticed is the slightly smaller requirement of fuel to burn the clay. The

ESSENTIAL INPUTS FOR CERAMIC INDUSTRY

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INTRODUCTION

Ceramic industry in India today accounts for about Rs. 1600 crores investment amongst 3963 factories. The output of the ceramic industry as per ASIC 1988-89 have a total output of 1167.4 crores providing thereby an employment to about 1.5 lakhs workers. The value added of the industry is 31015 lakhs. The industry has witnessed a spectacular growth and had been instrumental in providing employment to large number of people.

In Gujarat, the ceramic industry accounts for about 49% of the value of output and accounting for about 57% of fixed capital investment in the industry. The industry has great export potential due to availability of large resources of clay minerals. Abundant resources of clay minerals in the country, include Blue-clay, Fire-clay, China-clay, Bentonite, Plastic clay, with Quartz, Felspar, Sillimanito, Kynite rytile Zircon as hard minerals. As on latest data available on 1st January, 1985 whereas on 1st January, 1991, the total resources of coal is stood on 1,96,023 MT, crude oil 806 MT and natural gas 730 MT. the value of principle minerals produced is placed at rs. 16,903 crores wherein Gujarat accounted for 9.93% share in the total production of mineral production by value. In absolute turn, the figure is stood on 1679 crores in the year 1990-91, occupying 4th position in the production of value.

Similarly, natural gas produced in Gujarat was 1207 million cubic metres, out of total production of natural gas of 11,744 million cubic meters of the country. Lignite is produced only by the 2 states in the country viz. Gujarat and Tamilnadue. The total production of Lignite is stood at 151 lakhs tonnes of which 30 lakhs tonnes was mined from Gujarat and remaining from Tamilnadu.

In addition, Gujarat was blessed with ceramic raw materials, chief among them being fire-clay and china-clay. Thus the state offers excellent potential for setting up ceramic industry in the State.

Ceramic industry in the country mainly comprises of clay products, earthern-wares, china wares. As per ASIC survey, there were majority of the clay product factories located in the various parts of the country which mainly included refractory and glazed tiles. Earthern wares and china ware units were limited in number but have substaitial invested capital.

Major inputs for ceramic industry is considered as fuels. However, we may have to consider the following issues. 1. Land, 2. Power, 3. Machinery, 4. Man Power, 5. R&D facility, 6. Finance.

Process	Size Separation by Levigation & Hydrocyclone	Froth Flotation —	Magnetic Treatment HIMS	Chemical Treatment Acid leading, Bleaching etc.
Benefit	• Improve Puruity • Improve Plasticity • Improve Strength • More fine Particles • Improved Mineralogy	• Improve Purity • Improved Mineralogy	• Improve Purity • Improved Mineralogy	• Improve Purity • Improved Mineralogy • Improve Brightness
Technical Evaluation Tests	• Chemical Analysis • Particle Size Analysis. • Mineralogy • Strength • Firing Tests	• Chemical Analysis • Firing Tests	• Chemical Analysis • Firing Tests	• Chemical Analysis • Brightness Test • Firing Tests

Fig. 4.1 : Various Processing Routes.

(a) Size Separation by Wet Screening to less than 50 micron
(b) Hydrocycloning to particles less than 20 micron
(c) High - Intensity Magnetic Separation (HIMS) of the Product

Fig. 4.2 : A typical example of Process Routes employed for purification of China clay.

	Si02	Ti02	A1203	Fe203	Ca0	Mg0	K20	Na20	LOI	%2Micron	1200C	Fired colour Yield %
Wet Screening Feed	82.5	01.10	10.7	0.03	0.15	2.35	0.12	2.95-	--			
Process (2) Product 50 mircon	54.9	0.32	30.6	1.21	0.11	0.37	2.51	0.29	9.69	39	71	25
Hydroycloning 50 micron	54.9	0.32	30.6	1.21	0.11	0.37	2.5	10.29	9.69	39	71	-
Process (2) 20 micron Product	46.4	0.22	37.5	1.10	0.12	0.25	1.89	0.13	12.29	50	85	75
High Intensity 20 micron magnetic Separation (HIMS)	46.4	0.22	37.5	1.10	0.12	0.25	1.8	9 0.13	12.29	50	85	
after HIMS	46.8	0.10	38.0	0.81	0.12	0.25	1.37	0.10 12	44	52	89	90

Note : Overall, yield, Process (a) - (c) is 25% of 75% of 90% i.e., 17%

Fig. 4.3 : Chemical Analyses of Processed China clays obtained after various treatments.

Efforts have also been made to utilise scattered gas pockets of Dholka, Vijapur, Dehgam, Vaso for ceramic units. Scattered gas pockets may be exploited either by Gujarat Gas Co. promoted by GIIC or may be thrown open through private sector. It is also planned to have ceramic estate near Pipavav area wherein large units can take shape utilising the gas available from the land falled in.

MACHINERIES

Presently as per DGTD, there are 4 organised sectors machinery manufacturers in the country. Most of them are located in Punjab, Orissa and West Bengal. These units include Kusum Engineering, Harienthra Udyog Rajganjpur, Hindustan Hydraulic, Jalandhar and Rastriya Engg. Works, Bhatala. In addition, there are other organised sector units manufacturing ancillary machinery for the ceramic industry. The installed capacity of the unit in the organised sector manufacturing units is estimated at Rs. 500 lakhs per annum. The production in capacity utilisation of this unit has been at 30%. There is cope for the manufacture of sophisticated items of ceramic machinery which can be partly classified as under :

1. High capacity de-airing pug mills for all applications including the machines for manufacture of ceramic required for high tension electrical transmission.
2. Heavy duty filter presses, tile presses and counter current type mixer and tile glazing lines.
3. Anciliaries for tunnel kilns for various applications.

There is also scope for foreign collaboration for specialized type of equipments, one of critical equipments required by this industry is spray dryer which indigeneous machinery manufacturers have successfully manufactured and supplied this equipment. With the development of chemical industry and cement industry in the country, indigenous machinery manufacturers has already been developed to manufacture any machinery required for the ceramic industry.

In addition, there are many small scale and anciliary units which manufacture good quality machinery used in ceramic industry. Some of the items like Ball mill, blunger, pugmill, spray drier, kilns, furnaces, filter press, hydraulic moulding press are manufactured. Shuttle kiln or tunnel kilns are also manufactured by local manufacturers. Klin furnitures like saggar, refractory trolly, insulating bricks, mortar, ramming masses and castables are manufactured by leading refractory companies. Manishri refractories, Tata Refractories Ltd., Orissa Industries Ltd. are leading units who have also made a significant break through in exports to number of developed markets.

MAN POWER

No systematic work has been carried out with respect to the requirements of technical personnel for the ceramic industry. However, Directorate of of Technical Education, Gujarat has made a demand for engineering personnel in ceramic industry in the State. Ceramic industry being the highly labour intensive because of the process involved are not operated and is less manpower intensive at the same time provide to employment to one man per one kg. weight energy. The employment-energy ratio is one of the lowest. Further, it is a low capital intensive and all the raw materials required for the industry within the State. The industry is potentialto utilise local skill and manufacturing process are simple and therefore offers excellent opportunities for desirous entrepreneurs. A systematic attempt was made and a syllabus was developed and was compositions is merge. It is mainly available in the States of U.P. (3.0 million tonnes) and M.P. (1.11 million tonnes). Sericitic pyrophyllite which contained appreciable amount of alkalis (K_2O + Na_2O) is also available in large quantity in those States. The author has carried out extensive work at Central Glass & Ceramic Research Institute, Khurja Centre, regarding utilisation of Pyrophyllites/Sericites and found that an incorporation of 22.5 wt.% of the material in the whiteware composition increased the fired strength and decreased the percent thermal expansion.

Good quality Phyrophyllites and Sericites can be used in the manufacture of bonechina and also in whiteware glazes. Pyrophyllites can replace molochite/calcinted clays and sericites in partial replacements of potash feldspar and molochite/calcined clays in the glaze composition. Availability on regular basis of consistent quality pyrophyllite to the Indian whiteware industry is a problem which warranted its extensive use in the industry. Suitable action is needed in this direction to resolve the issue.

Sillimanite Beach Sand in Whitewares

The use of sillimanite group of minerals having the composition Al_2SiO_5, in the manufacture of refractories is well known. But the investigation of practical significance, use of sillimanite beach sand in replacement of quartz has been achieved in whiteware for development of high strength, volume stable and thermal shock resistant ceramics. More work is needed in this direction for the benefit of whiteware industry.

It is needless to emphasise that continuous exploration and research may reveal many more new raw materials for potential use in ceramics.

Body Processing Units for Whiteware Industry in the Small Scale Sector.

Whiteware industry in the small scale sector in our country is in crisis with reference to raw materials, technology, energy as well as marketing. Problems related to the supply of raw materials & processed bodies are only dealt here. Due to lack of infrastructure and finance the industry in the small scale sector had to depend on a number of ancillary units and agencies who supply them the required raw materials, processed bodies, glazes, colours etc. apart from looking after marketing and other related work. The small entrepreneurs mostly fail to identify the variations in the quality of raw materials and other inputs and they suffer very badly. The quality of material they produce is sometimes substandard.

All these above problems can be permanently cured through setting up of Modern Processing Units and supplying standardised ceramic bodies & glazes from there to the small units in out country. Some units in the form of Service Centre are, although existed but they are not well equipped to cater to the varied needs of small scale units under present changing situation.

DGTD may launch appropriate programme in this direction.

Setting up Institute for Whiteware

An Institute for Whiteware may be set up in order to cater exclusively to the various needs of whiteware industries including the problems related to raw materials on the lines adopted by Cement Research Institute of India and British Ceramic Research Institute, U.K. The institute may be funded and run jointly by DGTD and whiteware Industry. Such an approach was initiated at DGTD under the stewardship of Sri N. Biswas in 1987 but the institute is yet to set up.

It is felt that DGTD may once again take appropriate action in this direction and expedite the matter for the overall benefit of whiteware industry.

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CONCLUSION

Though land, basic raw materials and technically skilled man power are available throughout the country as well as in Gujarat, however the industry acute crissing of fuel. Further, the industry also need technological inputs information of upgradation modernisation and development of new products and process. The major input to ceramic industry being energy it also requires special attention for energy conservation through energy audit. If the efforts are made sincerely in these directions there is no doubt in our mind that the industry will prosper and have bright future for investment as well as exports.

As regards Gujarat, 31 projects with an aggregate investment of Rs. 1,485 crores will be implemented in coming years. Further a high tech ceramic panel formed by Government in Industry Mines Department with Secrtetarial located at Industrial Extension Bureau has been able to identify 10 areas based on Alumina powder which offers scope for investment. This will go a long way to attract more and more investment in the field of ceramics in Gujarat.

BENEFICIATION OF CHINA CLAYS CURRENT PROBLEMS AND CHALLENGES

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INTRODUCTION

China clay, which contains kaolinite as the principal mineral has wide use in paper, paint, ceramics, rubber soaps and detergents and many related industries. It is also a cheap raw material for the synthesis of materials like zeolites and molecular sieves for advanced applications. The paper industry, even today, is the largest consumer of kaolin clays, where very restrictive specifications exist. This is principally because the top technologies in paper manufacture use kaolin clay for manufacture of goods quality paper. The specifications for kaolin in paper industry sets severe limits on properties such as viscosity, particle size distribution, colour and brightness. MJost of the kaolin clays,due to their impurities, are unsuitable for use in paper industry.

The impurities present in kaolin clays are oxides and hydroxides of iron, ilmenite, rutile, anatase, quartz, fledspar, mic and graphite. Of these, these colouring, impurities such as the iron oxide and ilmenite, rutile and anatase are of chief concern. Hence the focus has been on the removal of these impurities in clays for suitable application.

The fine particle nature of the clays poses serious processing problems and there are attempts in literature which address this problem. This paper outlines some of the beneficiation methods and problems associated with benefication of china clays.

BENEFICIATION METHODS

A number of beneficiation methods are available for beneficiation of clays and those which are relevant to the removal of colouring impurities in clays will be briefly dealt here.

Wet Processing

Wet processing in one of the conventional methods of beneficiation which results in products of improved uniformity and brightness. By adopting specialised techniques within the wet processing significant colour improvement can be made. This method has been practiced by many clay processing industries.

Wet processing involves the following steps :

A. Mixing of crude clay with water and a deflocculant.

B. Separation of coarse material by screening, sedimentation and cyclones.

C. Chemical treatment to improve colour.

D. Dewatering by filtration.

E. Drying & pulverising.

WASHING

During the calcination, some soluble salts are produced as co- products of complex reactions taking place during heating. When the calcined mass has been ground, these salts must be washed out of the stain. If soluble salts are not removed by washing, it may lead to scummy colours. Chromium colours are particularly susceptible to this and should be washed very throughly. The washing process should be repeated untill the water comes off clear and colourless. Washing is the one of the important process in production of ceramic stains.

DRYING

After washing, the stains are dried and crushed to the required particle size. A distntegrater or pan mill is employed to achieve this. Printing colours can be ground too fine to produced satisfactory results.

GREEN COLOURS

Green colours are mostly prepared from the chromium compounds. Other elements used to produce green are copper, nickel, berylium and vanadium. Chromium compounds produces very wide range of green stains.

Normally chrome-green colours are very dark but when they produced with calcium compounds gives different shades of green which are lighter in tones. While with barium compounds in place of calcium produces little darker in shade. Nickel-chromium combinations produce grey green tones of pleasing softness. Zircon has been used to stabilise the chrome-green colours.

Copper green colours are very unstable at high temperature. Copper colours are always transparent. High lead glazes will produced deep green with copper oxide. Copper and vandaium combinations are used for producing very stable clear greens.

BLUE COLOURS

The combination of oxides used to produce blue stains for all temperature ranges are cobalt silicate, cobalt aluminate, cobalt phosphate, cobalt oxide, zinc oxide, silica, vanadium oxide and zirconium oxide. Brilliant blue colours are produced from cobalt compounds. There is a great variety of strength and tints of blue available from the use of cobalt and certain modifying agents. Flow blues are produced due to volatisation of chlorides. Cobalt chloride is used to produce flow blues.

Vanadium oxide and zirconium oxide with silica in presence of alkali fluorides produces range of blue and green stains. The colours should be calcined at 800 and 950°C in reduction atmosphere. Excess of vanadium oxide does not give greater intensity of colour.

PINK-RED AND PURPLE COLOURS

The commonly used compounds to produce red and pink ceramic colours are iron, chromium, selenium, cadmium, gold, copper and manganese. Uranium can also produce brilliant red stains in glazes. Red colours for high temperature is yet to be developed.

b) ***Sensitivity to treatment chemicals :***

Anatase removal processes is sensitive to ionic environment. The concentraqtion of chemicals chosen also varies from clay to clay.

c) *Dewatering :*

Techniques like carrier flotation, froth flotation and selective flocculation operate well at low solids content and the cost on dewatering is going to increase.

Advanced techniques like high gradient magnetic separation are still in a primitive stage in our country. The process will became economical only at higher throughputs. Commercial units are yet to be built.

CONCLUSION

In summary, refining of low-grade clays poses serious problems and challenges. Although there are a number of established methods are available, the effectiveness of the methods to a given situation needs to be established. Since the quality of clays and the impurities associated vary from deposit to deposit, it is important to characterise the nature of impurities in a given deposit and evolve 'deposit specific' beneficiation methods.

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2.	Cobalt phosphate	23.5
	Zinc carbonate	39.5
	Aluminium oxide	37.0
	Calcination Temp.	1300°C.

Pink :

1.	Pottasium Dichromate	3
	Calcium carbonate	31
	Stannous oxide	60
	China clay	6
	Calcination Temp.	1250°
2.	Chromium Oxide	0.5
	Calcium carbonate	21.0
	Tin oxide	55.0
	Flint	14.5
	Boric Acid	9.0
	Calcination Temp.	1250°C.

Brown :

1.	Manganese dioxide	16
	Iron oxide	45
	Zinc Oxide	39
	Calcination Temp.	1250°C.
2.	Chromium oxide	21.6
	Iron oxide	25.7
	Zinc oxide	37.2
	Feldspar	15.5
	Calcination Temp.	1250°C.

RECENT TRENDS IN CERAMIC KILNS' DESIGNING

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The kiln in various shapes and sizes firing wood/coal have been known to the potter/ceramist for times immemorial. Kilns were notorious to be some ugly structure located in the most inconvenient part of the factory and known to be a frustrating exercise to any free flow production program.

In the production of ceramic materials, the cost of production is divided into three main elements :

(a) Raw materials C.cost.

(b) Labour Cost.

(c) Firing Cost.

A. Raw Materials Cost :

The Raw Materiaals costs have not changed appreciably for the last few years and the cost of Raw Material also depends directly on the quality of the products to be produced.

B. Labour Cost :

The labour cost have increased substantially over the last few years. Because of this labour cost increase the kiln/equipment designer offer various combinations of automatic handling system for the wares as far as possible. The Labour cost have become very appreciable and it has become difficult to get qualified and skilled labour, in Europe, particularly on week ends. More and more kilns/equipments are being designed to work 5 days/week and a number of labour saving devices are being developed to reduce the requirement of labour. Also the reduced manual handling of the wares reduces the damage to the green wares.

C. Firing Cost :

The firing costs have seen increases in geometric proportions, particularly after the energy crisis of 1973. The steep hike in the enegy costs propelled the potters/ceramists to appeoach the kiln designers to find ways and means to design the kilns, which could be fuel efficient, more versatile, rapid fire tyupe to reduce inventories in all departments. In his endeavour to achieve the above goals the kiln designers have been actively supported by the ceramists in development of some raw materials in body compositions, glazes etc.

The Kiln Construction Materials :

The kiln designers started looking at the materials used in the construction of kilns & kilncars. Normally the kilns were constructed with hard brick materials to suit operating temperature. These hard bricks were backed by different grades of bricks, making very thick and dense composite

Today modern kilns are being provided with computers, which provide the working datas at a glance depending upon the inputs. The five distinct sections of the operation with computers are as followsm :

- Control
- Monitoring
- Data displays
- Retort Generation

The computers have a direct control on the firing zone temperature, firing chamber pressures, pushing speed or conveying speed as the case may be. The set point can be easily adjusted through the computer key board and all the kiln functions can be monitored continuously like temperature profile, kiln pressure, gas/oil flow, electrical power input, oxygen level, push or conveying speed and pressure status of inputs from the combustion air and exhaust fan systems.

With the generation of the above parameters, the kiln operator can have a complete overview on the kiln firing parameters and the varieties of the firing trends can be achieved with the press of a single button. Fine programme, which is feasible through these computers, to change the firing pattern of the kiln without much difficulty and going through the long consuming procedures of changing the parameters to achieve the desired temperature.

The modern kilns are capable to start up within few hours and close down at will, which was not possible in the conventional kilns, which took days to start up and weeks to cool off.

The Kiln Operation :

These days the entire kiln operation can be programmed so that the kiln can be operated with minimum manual supervision by automatic equipments, complete with kilncar movement/conveying system with minimum manpower. The kilns can be switched off at week ends, if required.

Type of Kilns :

From the conventional kilns like down draft kilns, chamber kilns, shuttle kilns and tunnel kilns, the latest trend is for the construction of newly designed kilns.

Following type of new kilns are in general use :

Tunnel kilns

Shuttle kilns

Roller kilns

(1) Tunnel kilns

Tunnel kilns are the most widely accepted equipments being used for sanitaryt-ware and crockery. The kilns are pre-fabricated and modular in construction and can be dispatched from the manufacturer's factory fully lined and the complete kiln can be installed in 2-3 months as against the conventional kilns, which use to take 6-9 months also needed very special foundation.

LAND

Gujarat Industrial Development Corporation (GIDC) offers land as the infrastructure providing social and infrastructure for setting up the units in the State of Gujarat. The Corporation has so far set up 193 industrial estates and have completed 11,847 and 11,706 housing quarters and have acquired 15,032 hectares of land of which 10,009 hectares of industrial plots have been developed. Out of this GIDC allotted 11,480 sheds, 10,359 housing tenaments and 7,286 hectares of plot area as on 31st March, 1992. During the year 1992-93, the State has planned to set up 30 new industrial estates and will be completing 358 sheds and 630 quarters. The Corporation also proposes to acquire land of 3,760 hectares and will be developing 4,578 hectares of plots. GIDC has already made development expenditure of about Rs. 340 crores and have planned to have a total expenditure towards development of about Rs. 80 crores. It is also planned to spend about 50% of the expenditure in the backward area of this State. the Corporation has also planned to set up a functional estate in Surendranagar especially for ceramic units.

POWER

The demand of power in Gujarat is estimated at 3915 mega watt and is expected to increase to 5486 mega watt by the year 1996-97. During the VIII plan, the State has planned to add 1661 mega watt in its installed capacity. In addition about 10 power generation projects have been planned by the end of the decade. Gas is the major inputs for the ceramic industry for which the State has already requested 12 MCMD being emphasised including the need for evolving National Energy Policy. The State has estimated the demand of power to increase @ 12-15% and in line with we had new projects in pipe line, the State has also been striving for generating power from non-conventional energy wherein Gujarat has baggged 4 out of 8 shield for outstanding performance in various areas of non-conventional energy sources and has achieved to commissionwind form at Lamba for a capacity of 10 mega watt in 1991. There is also a proposal to set up 100 mega watt wind form project at Dhankad (Rajkot). A proposal for generating power from tidal energy for a capacity of 900 mega watt in the gulf of Kutch is awaiting CEA clearance.

Other alternative inputs are natural gas, coal, lignite, LDO and furnace oil. Coal is the major input which is required to be hauled over a distance of 2000 kms. from eastern parts of the country. The scarcity of the coal adversely affect the production. The quota of coal allotted are not guaranteed for the regular supply.

In order to mitigate this shortage, an efforts are also a foot for gasification of coal deposits of the district of Mehsana wherein 63 billion tonnes of coal reserves are available at the depth of 1700 mtr. It is estimated that about 15000 billion cubic metre of natural gas may be generated through this source alone. ONGC after exploration of 2 wells vertically upto the depth of 1100 metre intends to join these wells urgently. ONGC has shown the willingness to join the hands with multinational companies for gasification of coals. If this motivate is fructified then ceramic industry problem of fuel can be solved.

Kachchh and Bharuch has partly solved the problem of roofing tiles units of Morbi. GMDC is supplying lignite for the hofkiln kiln which has come in blessing for the roofing tiles units in the State. The State is also fortunate to have a large deposits of natural gas as explained earlier. These deposits are located in the districts of Baroda, Bharuch, Kheda and Ahmedabad. The supply of gas to Kadi and Panoli with GIDC has attracted many units in these areas.

Bone China	Biscuit	1240 Oxisdising	4-12 2000-3800
Glost	1150 Oxidising	6-9	1200-2000
Glost	1150 Oxidising	2-9	3500-4500
Decoration	1000 Oxidising	0.5-6	900-1000
Soft Biscuit	1240 Oxidising	4-12	1500-3800
Porcelain Glost	1150 Oxidising	6-9	1200-2000
Decoration	1000 Oxidising	0.5-6	900-1100
Vitreous	Biscuit	1280 Oxidising/ hotelware	4-12 1500- 3800 reducing
Glost	1050 Oxidising	6-9	1200-2000
Decoration	1000 Oxidising	0.5-6	900-1000
Hard Biscuit	1000 Oxidising	8-12	800-1000
Porcelain Glost	1400 Oxidising	8-12	800-1000
Decoration	1250	Oxidising 9.5-6	1500-3500
Stoneware Biscuit	1000 Oxidising	8-12	800-1000
Glost	1320 Oxidising/	6-10	2000-4500 Reducing
Earthware Biscuit	1180 Oxidising	8-12	1000-1500
Glost	1050 Oxidising	6-10	800-1300

4. Future of Kiln Design :

In todays world the kiln designers are working towards using new materials and also working on use of heat resisting alloys for high temperature regions of the kiln and for further development on existing non-metallic materials, which shall offer excellent thermal conductivity and stability at elevated temperature. There will be increase in the use of silicon Carbide in various formulation in kilncar furnitures. The combustion system will also be improved upon such that the burners developed will ensure confirm with environmental requirements and waste gas emissions.

All our friends are aware that sticter emission laws ar ebeing enforced in the world including mIndia. Deadlines have been set for the automobile manufacturers to reduce emission levels to a predetermined value for the automobiles, which will be on roads after 1995 and this level will be furthe ryear 2000. When these control will become universal, they will also be applicable to fossil fuel firing system and combustion equipment will be viewed on these context.

In conclusion, we can say that in the last few years the kiln technology has advanced significantly and there is no reason, why this trend should not continue, so that the customers anticipation can be met upto their satisfaction.

recommended by the Committee that the first degree course in ceramic technology with in take capacity of 10 students at appropriate institution preferably MS University, Baroda may be started. Further, it is also recommended to increase the intake capacity in diploma in ceramic technology at LE College, Morbi from 15 to 30. It was also recommended to strengthen the laboratory facility and re-orient Curriculam at LE College, Morbi. It was also recommended to start new diploma course in ceramic technology with intake of 15-20 students preferably at Ahmedabad. It was also recommended to start craftsmanship training programme in ceramic trade in ITI at Surendranagar, Rajkot, Ahmedabad, Himatnagar, Visnagar and Baroda.

It is high time that one should look upon the implementation of the recommendations of the sub-committee and also augments further the training programmes in the state with a view to keep pace with the development of ceramic industry in the State. Similarly, ceramic technology branches in natural Universities like Varanasi, Jadavpur may augment the present Curriculam and places which are devoid of such facilities may initiate steps to create such facilities for the availability of technically skilled manpower in the country.

RESEARCH & DEVELOPMENT

With the development of the ceramic industry, the use of various ceramic raw materials have been finding places in the new areas. High tech ceramic has drawn special attention of the State and the State has set up sub-committee for the development of high tech ceramic units in the State. The panel through "Dalal Consultants" has identified investment opportunities in the high tech ceramic. However, the technology for the manufacture of high tech ceramic may not be available and therefore would require the development in the country. Gujarat being rich in superior grade bauxite, the State offers excellent opportunities for alluminium powder based high tech products and require R&D inputs. Some of the areas which are identified include, (i) Grinding media, (ii) Multilayer capacitors, (iii) Ceramic thread guide, (iv) Ceramic Sensors, (v) Ceramic cutting tools, (vi) Alumina Powder.

These areas would require special inputs from institutions engaged in the research and development in the country. Central Glass and Ceramic Research Institute with its headquarter at Calcutta and extension centre at GIDC Naroda can take up the challenge for the development of new process and products in the field of ceramics. In addition, Bharat Heavy Electricals ALtd. Bangalore and Director of General for Technical Development may also initiate further action so that newer products and processed are available for investment in the field of ceramic. Latest developments in Japan and U.S.A. of the like of ceramics in neculear, automobiles, electronic and pharmaceutical. There is also wide scope for new materials like composite ceramics.

FINANCE

Financial Assistance to ceramic units are made available by All India Financial Institutions which include ICFCI, IDBI, IFCI and State Financial Corporations. In addition, venture finance is made available for projects involving risk of success in case of indegenious technology of areas wherein first attempt is made to explore.

There are two such financial institution new technology and products set up in the country as in Andhra Pradesh and other in Gujarat. Gujarat Venture Finance Capital Ltd., a subsidiary of Gujarat Industrial Investment Corporation Ltd. offers such facilities of the entrepreneurs, while working capital finance is available through scheduled bank.

Development of shuttle and tunnel kiln in SSI sector in Gujarat

Year	No. of shuttle kiln	No. of Tunnel kilns	Remarks
Upto 1982	-	3	For L.T. Insulators only,
1983	-	2	
1984	4	-	For sanitary wares
1985	4	1	
1986	5	1	
1987	7	1	
1988	8	2	
1989	39	5	
1990	40	7	(a) Kilns with ceramic fibre (b) Crockery, glazed wall tiles and sanitary wares.
1991	44	14	
1992	45	18	
Total	196	52	

Source : From field ... luring ... 92 by S ... ıbad.

Shuttle Kiln

Shuttle kiln is a rectangular periodic oil fired kiln in which the products are loaded on car with support of various kiln furniture and pushed on rails inside the kiln chamber which is either refractory lined or ceramic fibre lined. Two kiln doors provided move on hinges. After firing, the car is taken out at temperature of about 150°C from one door and previously loaded other car is pushed inside the kiln through the other door for next firing. This system reduces the energy losses caused by cooling down the kiln to the room temperature as in case of DD kilns and resultantly give more firing cycles. Fuel cost also gets reduced in shuttle kiln, that can be seen in Table No. 2 and 3.

The year 1984 was the beginning of shuttle kilns in Gujarat in SSI sector. The first indigenous shuttle kiln which was installed in THANGADH was conceived by M/s. Sharma Kiln Technology, Ahmedabad. Rapid growth in use of shuttle kilns was taken place during and after 1989. There may be now around 200 shuttle kilns mostly installed for the manufacture of sanitary wares in SSI units in Gujarat.

Tunnel kiln :

Tunnel kiln consists essentially of a long straight tunnel of relatively small internal area divided into three zones namely pre-heating, firing and cooling. The wares are loaded on cars with the help of refractory furniture and pushed mechanically or hydraulically inside the kiln on rails from pre-heating zone and taken out from cooling zone. The temperature encountered by wares as it moves through tunnel increases and then decreases gradually as in an intermittant kiln (D.D and shuttle kiln). The kiln structure is so designed that particular part in the kiln remains at a constant temperature and does not change with time. Tunnel kiln conserves the fuel energy by eliminating the need of periodic heating up and cooling down of the kilns walls as in case of DD kiln and shuttle kiln.

Salt Glazed Stoneware Pipes

This industry is yet to find a better alternative to the age old coal fired down draught kilns.

Shuttle or Tunnel kiln may not be suitable for Roofing tiles or Salt glazed stoneware pipes.

Sanitarywares

This industry which was confined to only large scale sector till early eighties and from the very beginning is working with car- Tunnel kilns. Those tunnel kilns installed in large scale sector are imported and obviously of high investment.

Although sanitary ware industry in SSI sector first started with conventional D.D. kilns, it is now successfully working with indigenous shuttle and tunnel kilns. There may be around 135 s.s. units in Gujarat. D.D. kilns have been totally discarded by the industry.

Table No. 2 provides some data (based on assumptions) on the manufacture of one MT of sanitarywares for comparison among (a) D.D. Kiln, (b) Shuttle kiln and (c) Tunnel kiln.

Table No. 2

Data on the manufacture of one M.T. of Sanitarywares for comparison among (a) D.D. Kiln, (b) Shuttle kiln and (c) Tunnel kiln in Gujarat (January '93)

Sr. No.	Factors	D.D. Kiln	Shuttle Kiln Ceramic Fibre lined	Tunnel Kiln Refractory lined
1	2	3	4	5
1. (a)	Kiln size	18' dia	21 m^3 (with two cars)	0.9 x 0.65 x 33 mtr (WHL)
(b)	Output	10 MT/cycle	2 MT/cycle	4.5 MT/day
(c)	No. of cycles per annum	36	192	-
2.	Investment on the kiln	Rs. 6 lakhs	Rs. 10 lakhs	Rs. 18 lakhs
3.	Fuel	Steam coal	L.D.O.	L.D.O.
4. (a)	Fuel consumption per MT of production	2.0 MT	400 ltr.	440 ltr.
(b)	Cost of fuel (considering total cost of production @ Rs. 9000)	Rs. 4000	Rs. 2600	Rs. 2860
5.	Duration of firing cycle			
	(a) firing	48 hrs.	12 hrs.	10 hrs.
	(b) cooling	96 hrs.	12 hrs.	10 hrs.
	(c) Total	144 hrs.	24 hrs.	20 hrs.
6.	Qty. of kiln furniture (in MT)	1.8	0.8	0.7
7.	Quality of production (figures in percentage)			
	(a) I & II class	10	50	50
	(b) III & IV (or commercial)	60	40	40
	(c) Rejections	30	10	10

Source : From field study

CROCKERY (Stoneware variety)

The manufactory of stoneware variety crockery in Gujarat is predominently in SSI sector. There may be around 70 working units. Almost all the units with a few exceptions are still working

6. Iron: Yellow to red
7. Manganese: Pink violet and brown
8. Prasmodium: Yellow
9. Selenium: Red
10. Uranium: Red, brown and black
11. Vanadium: Yellow, green and blue

Ceramic colours consist of crystalline solids and their properties depends on the properties of crystal latices constituting them. Most of the ceramic stains have crystal structures that are unusable at high temperature.

Various methods are used to prepare ceramic colours. Each stain requires its own special treatment, such as dry or wet mixing, calcination temperature and blending of materials. Ceramic colours can be produced by the following processes.

BLENDING

Following processes are used commonly to blend different raw materials.

(a) Wet grinding for raw materials which are insoluble in water.

(b) Fusion of hydrated metallic salts.

(c) Co-precipitation of aqueous solutions of metallic salts.

(d) Using aqueous solutions of colouring salts to impregnate-such as silica, alumina, china clay etc.

The most common method of blending is wet grinding which is usually done in a ball mill or jar mill. The degree of reduction of particle size affects the rate of reaction during heating.

Dry grinding does not produced the necessary degree of homogeneity. For water soluble metallic salts, the salts are dissolved in hot or cold water and subsequently mixed with the dry components. After the material has been well mixed or milled and dried, it is placed in refractory containers i.e. sagars and then calcined.

CALCINATION

During the calcination process, the gases and other volatile matters go off and the colours are developed and stabilised. Calcination is a controlled process. Each ceramic stains has its own temperature range for calcination and that is to be controlled very carefully. The atmosphere in the kiln used to calcine the stains is also important.

GRINDING

The purpose of milling unfired mixtures of colour producing materials is quite different from that of grinding calcined mass. The efficiency of grinding depends on the type of material being ground, the type of grinding medium and the fineness of starting material i.e. the ratio of particle sizes before and after milling.

new kilns. At present there may be around 20 units in small scale sector in the state of Gujarat and moreover all the units have come up with ceramic fibre lined shuttle and car tunnel kilns. It is expected that in near future units may come up with rapid firing Roller Hearth Kilns in the state.

Porcelain Electrical Insulators

The manufacture of porcelain electrical insulators in Gujarat predominently is in SSI sector with around 35 working units. About 20 units (most of them in Surendranagar district) are working with shuttle or tunnel kilns and remaining are still working with age old D.D. kilns. It is expected that D.D. kilns will be gradually discarded by this industry in near future.

Project Profiles

SISI Ahmedabad prepared project profiles (model schemes) on the following items based on new generation ceramic kilns (Shuttle or Tunnel) —

1. Stoneware crockery
2. Bone china wares
3. Elect. porcelain items
4. Ceramic tower packing materials
5. Unglazed ceramic vitreous tiles
6. Earthenware glazed wall tiles
7. Sanitarywares

The project profiles at a glance are givne in Table No. 4.

Table - 4

Abstract of Project Profiles on the manufacture of some ceramic products with the new kilns

(Rs. in lakhs)

	Project Profile (Product)	Year of Preparation	Total Project cost	Investment on Plant & Machinery	Working Capital	Capacity	Turn-over	Suggested kiln
	1	2	3	4	5	6	7	8
1.	Bone chinawares	1990	76.0	39.0	19.0	150 M.T.	105.0	Car Tunnel kiln
2.	Electrical porcelain items	1990	53.8	29.0	7.8	600 M.T.	54.0	Push bat tunnel kiln
3.	Earthenware glazed wall tiles	1991	102.0	46.5	12.0	1140 M.T.	97.0	Ceramic fibre lined shuttle kiln for biscuit firing & Tunnel kiln for glost firing.
4.	Sanitarywares	1991	64.68	23.0	7.68	855 M.T.	55.57	Ceramic fibre lined shuttle kiln
5.	Stoneware crockery	1992	57.80	28.0	7.80	600 M.T.	51.30	Ceramic fibre lined push bat kiln
6.	Ceramic tower packing materials	1992	56.45	25.0	9.45	900 M.T.	60.75	ceramic fibre lined shuttle kiln
7.	Unglazed ceramic vitreous (mosaic) tiles	1992	54.46	26.0	7.0	600 M.T.	48.45	Ceramic fibre lined push bat kiln

N.B. : The above project profiles can be made available on request, to the entrepreneurs from SISI, Ahmedabad.

Most stable pink stains are obtained from chromium oxide and stannic oxide combinations. Different shades from pink to purple can be produced by controlling the particle size of chromium oxide. Red glazes prepared from chromium have a tendency to crystalize. Presence of calcium oxide up to a certain quantity increases the redness of the stain. Addition of boron compound develops the red colour but in large amounts converts the red to lilac. Zinc oxide causes the pinks to turn brown. Chromium- alumina combinations will produce pink and red depending on the type of crystalline structure formed during the calcination at high temperature.

Iron oxides are used to produce a range of orange to blood-red colours for on-glaze temperatures. Cadmium selenium combination also produce red at 700° to 800°C.

TYPICAL COMPOSITIONS

All quantities are in percentage.

Green :

1.	Chromium Oxide	26
	Silica	74
	Calcination Temp.	1250°C.
2.	Pottasium Dichromate	36
	Silica	30
	Calcium fluoride	15
	Calcium carbonate	19
	Calcination Temp.	1250°C.
3.	Chromium oxide	25
	Cobalt oxide	3
	Feldspar	15
	Flint	50
	Calcium fluoride	7
	Calcination Temp.	1250°C.

Blue :

1.	Cobalt oxide	27
	Aluminium Hydroxide	38
	Silica	23
	Zinc oxide	12
	Calcination Temp.	1250°

ROLE OF GUJARAT GAS COMPANY LIMITED IN ENERGY SECTOR

Mr. M.K. Sinha
Dy. General Manager
Gujarat Gas Company Ltd.

A. INTRODUCTION

India is 2/3 self-sufficient in petroleum fuel and the import bill last year touched Rs. 12000 crores which is projected to rise steeply with growing demand of oil. The country is not in a position to bear such a heavy foreign exchange burden. Therefore, a search for alternate fuels has become crucial otherwise the rapid industrial development looks like for away dream.

With a special emphasis to Gujarat as it is situated at a distance from the coal mines of Madhyapradesh and Bihar, the Natural Gas is the only solution to the problem of power and other fuel shortages.

The Government of Gujarat has also recognized the importance of Natural Gas as a substitute fuel. To achieve the objective of economic use of Natural Gas as and when it is committed by Government of India, the State Government, through Gujarat Industrial Investment Corporation (GIIC) has set up a separate agency in associate sector, Viz. GUJARAT GAS COMPANY LIMITED, With M/s. Arvind Mafatlal Group to implement and manage gas distribution projects for domestic, commercial and industrial purposes.

The unique feature of the Company's existing projects is that these projects had been implemented based on in-house capability and without resorting to any import of know-how or equipment. The Company has adopted the strictest standards available in the world for design and operations of its projects. Recently expert teams from some of the leading inter-national gas distribution companies visited GGCL's installations At Ankleshwar/Bharuch & Surat and have certified the soundness of safety and operating standards. The company has embarked upon a decicated Research & Development program to improve locally available materials/equipments and develop new ones required for the gas distribution projects.

So far GGCL has completed distribution project at Ank/Bha. and Surat, the details of which are presented in Table II.

B. NATURAL GAS SCENARIO

i) NATIONAL

Natural Gas is used on a limited scale mainly for production of fertilizer. However, with the increasing availability of associated gas and recent discovery of free gas fields, the planning of natural gas utilization had undergone a major change. The new priorities are for production of power, fertilizer and for use as fuel. The current production of Natural Gas is around 49 million cubic meter per day. Of this, only 40 million cubic meter is being used, the rest of this is flared.

E. COST OF NATURAL GAS

In general, natural gas is most civilized fuel all over the world and it can be used as a fuel for any process such as steam raising, drying, heating, baking etc. This fuel also claims to be cheapest as can be seen from the graph attached.

TABLE I

AVAILABILITY AND REQUIREMENT BALANCE - 2000 AD

	Availability (MMSCMD)		Requirement (MMSCMD)
On-shore	2.7	Power	25.60
Gandhar	9.9/15.0	Fertiliser	7.50
Tapti	4.0/5.0	Large Inds.	2.63
Off-shore	23.7	Domestic	2.50
		Small/Medium Scale Inds.	7.50
	40.3/46.4		45.73

TABLE : II

GUJARAT GAS COMPANY LTD.

PRESENT PROJECTS

	ANK/BHA	SURAT	TOTAL
Qty. of gas (In m3/d)	170000	300000	470000
No. of consumers connected :			
Industrial	150	60	210
Commercial	200	60	260
Domestic	8600	8000	16600
Length of pipeline : (in km.)			
MS	47	45	
HDPE	210	110	
No. of Employees :	325	300	625

Type of industries using natural gas :
Chemical, Pharmaceutical, Engineering, Textiles, Ceramic, Dairy etc.

walls. These hard bricks had high heat storage, this means that the kiln needed a very large quantity of fuel for heating up as well as long time to achieve operating temperature. Presently, these have been replaced by light weight insulation bricks or ceramic fibre. These materials are lighter in weight and have lower thermal conductivity and low heat storage capacity.

The most important factor in the kiln designing is the use of lighter possible weights in the kilncars. The kilncars are components, which takes the maximum heat energy out of the kiln and this energy picked up is a total loss. The designers are on the look out of construction materials, which are lighter vis-a- vis, the weight of wares and those materials can withstand the thermal shock consistently. For carrying the wares, new type of slab support beams, made out of silicon impergranted or nitrol bonded silicon carbide beams are used. The filling insulation materials in the kilncars' centre can be mainly loose ceramic fibre.

Combustion System :

For combustion systems a lot of R & D work has been put in by the burner designers, who have produced burners and its auxilliaries of different modes firing to suit the particular method of firing, controlling temperature and fine tuned adjustments to fuel and air ratios. The burner are now available in medium and high velocity firing modes, besides the normal low pressure burners, which have been available for quit sometime and infact were the first step in the burner development when liquid and gaseous fossil fuels came in the vogue.

The use of medium and high velocity burners opened up many new vistas in thekiln designing, that is, the kiln cross sections started to change and also designers become more adventurous by designing the kiln with open flame firing configuration, wherever the wares permitted. In the medium/high velocity burners the combustion is completed within the burner block and it is only the products of combustion which flow into the kiln, moreover these burners can be fired with wide range reducing and highly oxidising range of (approx. 200%) combustion air, depending upon the kiln atmospheric requirement. The velocity of products of combustion leaving the burner block is int he range of 60-70 m/sec. for medium velocity burners and 120-140 m/sec. for high velocity burners.

Kiln Cross-section :

The kiln Cross-section from a position of tall narrow width setting changed over to wide and low settings. For example, the earlier kilns' approx. dimensions were generally of 800 mm. width and 1200 mm. height. While the modern kilns have a width of 2500 mm. or more in the Tunnel kiln and shall be more wider in case of shuttle kiln with setting height of 800-1000 mm. in the Tunnel kilns and upto 1500 mm. in case of shuttle kilns. These wider width and low setting cross-section have permitted the use of high/medium velocity burners to achieve uniform temperature in close tolerances throughout the sections of the kiln and as such rapid firing procedures could be carried out and firing cycle reduced appreciably.

Kiln Controls :

The kiln control and monitoring system has made significant advances in which the kiln parameters like temperature profile, controller sensitivity and accuracy, the kiln pressure control system etc. are available. The instruments are available for complete recording of various kiln parameters, fuel flow rates a air flow rates.

ENERGY ECONOMICS THROUGH CERAMIC FIBRE INSULATION FOR HEAT HANDLING EQUIPMENTS

Shri Mahesh Chavda
Manager
Murugappa Morganite Ceramic Fibres Limited, Madras.

The role of Energy Managers have always been given importance ever since the oil crunch of the 70s. Today, the industry can ill-afford to neglect even remotest possibility of energy conservation of finding alternate sources of energy.

While considerable research is perhaps going on to identify alternate sources from the conventional sources such as fossil fuel, coal etc. conservation of the present fast depleting sources of energy assumes very great importance.

We will in this presentation be looking into conservation of energy in the form of heat. Heat is a major energy input in many of industry such as Metallurgical, Petrochemicals, Fertilisers, Oil Refineries, Ceramics, Glass, etc.

The equipments which handle the heat input\output generally termed as furnaces or kilns. Primarily a furnace or a kiln is made up of a combustion system to provide the heat and insulation to contain the heat. To contain the heat and thereby direct this heat to the job, allowing little of ii is escape to the ambient to essentially the function of insulation in a furnace. We will dwell in particular on this aspect to see how the desire of optimum insulation is essential to the performance of the furnace.

Insulation in turn is expected to meet two basic requirements viz. (1) ability to withstand the temperature and (2) capacity of resist the flow of heat there to mass. The former is the measure of Refractories while the latter the Thermal conductivity (denoted usually as "K" of the material.

Let us take a look at the practice in the past espescially in the 60's. The furnace lining consisted of dense Refractories with high "K" values. The furnace was looked at as a "box" to keep the heat in, no matter how much heat the furnace absorbed in its lining. Although ceramic fibre was invented wayback in the 40's, its commercial usage did not pick up till the 60's. The main advantage Ceramic Fibre offered was, its capacity to store less heat (by virtue of its low density and conduct less heat flow(low "K" values).

CERAMIC FIBRE, THE PRODUCT : In India, Ceramic fibre was first produced in 1984. Today, Alumino Silicate Ceramic fibres are well known to the users and designers of Refractory insulation materials. Ever since the commercial production of Ceramic fibre in 1984. Indian consumers have been able to get the benefits of the product locally in terms of quick availability and economical costs. The versatile nature of this product for installation and maintenance has attracted the attention of users and designers to try to apply the product in various areas.

Ceramic fibre is produced from Alumina ($Al2O3$) and Silica ($SiO2$) by blending the two and melting the blend using electrical arc. The melt which pours out of the furnace at about 1800°C

On the contrary, the modern Tunnel kilns can be placed straight away on the normal buy floor and the kiln modules can be bolted together within a short time. This wide cross-section kilns have the advantage of reduced fuel consumption in firing the products. The kilns are fully programmed and controller through the computers and all the parameters can be controlled automatically as per the soft-ware.

It has been possible to fire the wares in the firing time of 50% or less than what was being done earlier. for example, sanitary- ware kilns have a firing cycle of approx. 12-14 hrs. from cool to cool.

(2) Shuttle Kilns :

Present, the shuttle kilns are designed in the width of as much as 5 mtrs. and above, depending upon the prodcut to be fired. The shuttle kilns are also being manufactured in modular construction with minimum foundation requirement. Thereby reducing installation time and resorting to expensive foundation requirement.

(3) Roller Hearth Kilns :

In the last 20 years the most significant achievement is the development of a most capable system. The Roller Hearth Kilns. In our own country imported Roller Hearth Kilns (approx. 25 nos.) are operating sucessfully for ceramic tiles industries, particularly for single firing of floor tiles. Ofcourse in our country, the floor tiles are being used in wall applications as well. Recently in Europe and other countries, the Roller Hearth Kilns have been adopted successfully for firing sanitary-wares and crockery as well. The Roller kilns have proved to be highly productive and helped to reduce the firing cycles for tiles upto 50-60 min. and for sanitary-ware 5-6 hours from cool to cool.

The achievable fuel consumption in the latest kilns for different products are given below :

1. Tunnel kilns for Sanitary0ware : 1100 KCal/Kg. + 10# at a firing temperature of 1250°C.

2. Roller kilns for single deck firing tiles - 350 KCal + 10%.

FUEL CONSUMPTION :

Tableware/Crockery

(Taken from M/s. DRAYTON PUBLISHED BROCHURE)

Product

Firing

Temp. C

Atmosphere

Cycle hours C to C (100% hollow-ware to 100% flatware)

Energy Consumption KCal/kg ware min output 0.5T per hr. (100% hollow-ware to 100% flatware)

(6) Ease of installation : The linings are simple to install and require no special masonry skill as the case is with the refractory lining.

The advantages thereby offered are :

1. Light weight furnaces.
2. Simpler steel fabrication work.
3. Low downtime.
4. Increased Productivity.
5. Additional Capacity.
6. Low maintenance costs.
7. Longer service life.

However Ceramic fibre is not the ultimate aim in furnace insulation. It needs to be used with caution and care.

1. It is not useful in areas which are prone to mechanical abuse.
2. Direct flame impingement is harmful to fibre.
3. In highly reducing atmospheres the 'K' values of Ceramic fibre are higher.
4. Very high temperatures (in excess of 1500°C) cannot be handled by Ceramic fibre.

Most furnaces would qualify for a fibre lining application by way of (1) direct full lining using combination of fibre materials (2) veneering a layer of fibre to the existing backwork (3) a back up insulation to the brickwork.

Since the manufacture of Ceramic fibre commenced in 1984, the usage has increased many times. Today there could be well over 500 odd users of this products for various applications.

Many users have realised benefits in terms of saving in direct energy costs and also indirectly by way of reduction, maintenance, cost reduction etc.

The major advantage of Ceramic Fibre linings by virtue of its Low Thermal Mass characteristics is in furnaces which operate around 1000°C. A typical case given below would make this clear :

Let us consider a Heat Treatment furnace of total area to be lined with fibre is about 50m2.

	Dense Bricks	**Ceramic Fibre**
Thickness	250mm	150mm
Hot Face Temperature	1000°C	1000°C
Cold Face Temperature	92°C	80°C
Heat Loss	800 Kcal/m2/hr	700 kcal/m2/hr
Weight	50 kigs/m2	150 kgs/m2
Heat Storage	26,000 Kcal/m2	2,700 Kcal/m2

The fuel savings are now only a setup of calculation away. I will leave the reader to do this. For every batch of furnace the possible fuel saving in this model furnace is less than 175 liters of oil which is more than Rs. 700.

NEW GENERATION CERAMIC KILNS AS CAPITAL INPUT IN SSI SECTOR OF GUJARAT STATE

K. V. K. Raju & R. P. Singh
S.I.S.I., Ahmedabad

Introduction

In ceramic industry the cost of fuel is major cost centre and ranges from 30 to 50% of the total cost of production. The expenditure on fuel depends on the thermal efficiency of ceramic kiln used for firing the products. Most of SSI Ceramic Units used down draught kilns till 1984 for their firing operations. The thermal efficiency of this kiln is only 3-10%. SSI ceramic units also experienced difficulty in obtaining good quality steam coal in adequate quantity for this kiln. All these problems agitated the minds of entrepreneurs in Gujarat and made them to switch over to alternate firing techniques of shuttle or tunnel kiln.

The technology of tunnel and shuttle kiln was imported and usedearlier by large and medium scale units. At that time, it was far beyond the investment limit for SSI sector. Even when such indigenous kilns were developed, their adoption by SSI units was exposed to limitations of :

(a) Financial vulnerability,

(b) Inadequate information about the suitability of the new generation ceramic kilns and

(c) Insufficient confidence and lack of experience in new firing techniques and with fuels other than coal.

Fortunately for this sector, Govt. of India increased the investment limit of SSI to 35 lakhs, whereby it became feasible for SSI to adopt shuttle and tunnel kilns with financial assistance from term lending institutions. The situation is much easier presently with the investment limit of SSI being Rs. 60 lakhs. By this time, SISI and indigenous kiln consultants were also ready to provide necessary information and guidance about the suitability and operation of these new generation ceramic kilns.

This process of actual changeover from down draught to shuttle kilns started in small scale sector in 1984 at Thangadh for firing the sanitary wares. The simplest shuttle kiln with one car was feasible within the investment limit of small scale at that time. The success of this kiln motivated many other entrepreneurs in Gujarat who also became aware of the following advantages of shuttle kiln over down draught kiln.

1. No dependence on quality and availability of steam coal; as the fuel used in shuttle kiln is L.D.O.
2. Reduction in firing cycle to 35%,
3. High thermal efficiency (30 to 40%),
4. Economy in fuel cost (20 to 35%).

The development of shuttle and tunnel kilns in small scale sector in Gujarat can be seen from Table 1.

guide the user in the right direction by making an in-depth analysis of the furnace and recommending the correct linings.

1. Density vs Thermal conductivity :

Generally for a given temperature 'K' value decreases with increase in density. However for the densities above 250 Kg/m3 the drop in 'K' value will be much lesser and beyond 400 Kg/m3 density advantage/achieving lower 'K' value by increasing the density will not be substantial.

2. Fibre insulation vs Refractory insulation :

Insulation properties of refractory material are mainly dependent on specific heat material and conduction of the material, whereas in case of fibre insulation by virtue of dropping the air in-between the fibreous heat will pass through individually fibre by conduction and also by way of convection through the air gap available. That is why generally, 'K' Value of fibre material are lessor than refractory material.

3. Life :

Ceramic Fibre has an excellent thermal shock and Chemical resistant capacity, Therefore suitably designed lining can provide much longer service life (beyond 10-12 years).

During the operation may be the hot face layer might need part/full replacement depending upon the operating conditions but generally the back up layers are lasting even more than 12-15 years.

Tunnel kilns generally used are primarily of two types : (i) Car type, (ii) Push bat type. Both the varieties are continuously operated. Oil fired push bat and car tunnel kilns were first introduced during early eighties in SSI units in Gujarat (Surendranagar & Baroda) for the manufacture of Porcelain Electrical Insulators. A crockery unit in Himatnagar installed car tunnel kiln for the manufacture of stoneware crockery in the year 1989 and a unit in Ahmedabad installed a push bat kiln for the manufacture of stoneware crockery in the year 1990. Subsequently, the use of car type tunnel kilns in SSI sector grew faster. It also coincided with the development of Glazed wall tiles industry and with the rapid development of sanitaryware units in SSI sector. The tunnel kilns which were considered not feasible in SSI sector till 1980 are becoming more and more common as far as Gujarat State is concerned.

Both Shuttle and Tunnel kilns are installed in covered sheds which makes their operation easier, less tiring and convenient.

CERAMIC FIBRE AS HOT FACE REFRACTORY AND HEAT INSULATION

The use of ceramic fibre lining in various types of kilns in our country is of recent origin. Both shuttle and tunnel kilns which are externally steel structures have been conventionally lined either with refractory bricks or with refractory cum insulation bricks.

The use of ceramic fibre lining in shuttle and tunnel kiln not only helps in achieving better insulation but also reduces wall thickness to 1/3 to 1/4 of conventional wall. It also ensures conserve of the fuel energy by way of reducing total heat mass of the kiln. The ceramic fibre has very low heat storage capacity and low thermal conductivity as compared to other refractory materials, thereby reducing the thermal losses. This all reduces the fuel cost as shown in Table No. 3.

The first "ceramic fibre lined shuttle kiln" was installed in Gujarat (Thangadh) in the year 1990. Its use has become just common in the case of shuttle kilns. There may be around 150 such shuttle kilns with ceramic fibre lining in Gujarat. The existence of M/s Orient Cerawool (P) Ltd., the producers of ceramic fibre in Gujarat has also significant role in the development of fibre lined new kilns in the State.

Similarly, the first ceramic fibre lined car tunnel kiln was also installed for the manufacture of porcelain insulators in Thangadh (Gujarat) in the year 1991, which was followed by a few more including one in Ahmedabad installed for the manufacture of stoneware crockery. While the shuttle kilns with ceramic fibre lining are already quite standardised and become popular, the ceramic fibre lining in tunnel kilns which is now in infant stage has wider and brighter future. Ceramic fibre has refractory cum insulation property and has its own inherent techno-commercial advantages over conventional refractory lining.

Status of use of New Kilns in Gujarat

The main ceramic products of Gujarat are — Roofing tiles, Salt glazed stoneware pipes, Sanitarywares Stoneware crockery, Show case articles, Porcelain electrical insulators, Fire clay refractories, Glazed wall tiles, unglazed floor tiles, Red bricks, terra-cota wares, grinding wheels, Electronic components, glass and enamelled wares.

Roofing Tiles

This industry which was once working with coal fired down draught kilns has already switched over to lignite fired HOFFMAN KILN.

CERAMIC FIBRE PRODUCTS AND THEIR APPLICATION FOR ENERGY CONSERVATION

Avinash S. Chitre
General Manager (Marketing)
Orient Cerwool Ltd.
Andheri (East), Bombay-400 069.

The high cost of energy continues to be a matter of growing concern to all industries, particularly those dependent on the more expensive energy sources. We feel certain, therefore, that you will be happy to know that the single most efficient energy saving product, namely CERAMIC FIBRE is now indigenously available.

In order to derive the maximum benefit from CERAMIC FIBRE systems it is necessary to understand its properties, limitation, design criteria and various applications as detailed below :

IMPORTANT PROPERTIES OF CERAMIC FIBRE PRODUCTS.

1. Very low thermal conductivity - (0.1 Kcal/mh deg.C. at 600 deg.C for 128 kg/m3 density blanket). About 50% better than good quality insulation brick, ten times better than fire bricks and 2.5 times better than asbestos products. More insulating than calcium sillicate product and other insulating materials.

2. Light weight :

(Average density - 96 kg/m3) : One tenth of the weight of insulating brick, 5% weight of fibre brick and one third that of asbestos/calcium sillicate boards.

3. Thermal shock resistant :

No matter how fast they are heated or cooled, the product form will not crack or spall.

4. Chemical resistance :

Resist most of the chemical attack, unaffected by hydro carbons, water and steam.

5. Ease of handling :

All product forms are easily handled and most can be quickly cut with a knife or scissors. Vacuum formed products may require cutting with bandsaw/hacksaw.

OTHER PROPERTIES ARE :

1. Asbestos free
2. Resilient
3. Excellent sound absorobtion
4. No curring or drying time
5. Velocity resistance to gases, tearing and abuse
6. No deterioration on storage - for Bulk fibre, Blankets, Modules, Boards, Rope etc.

with age old D.D. kilns. Two entrepreneurs in Ahmedabad and one in Himmatnagar have ventured and successfully installed a push bat kiln and car tunnel kiln (ceramic fibre lined) in their respective units. One entrepreneur in Ahmedabad has been working with shuttle kiln for last two years. This industry is looking forward for gradually switching over to new kilns.

Table - 3 provides some data (based on some assumptions) on the manufacture of one MT of Crockerywares for comparison among (a) D.D. Kiln, (b) Shuttle kiln and (c) Tunnel kiln.

Table No. 3

Data on the manufacture of one M.T. of "Stoneware Crockery" for comparison among (a) D.D. Kiln, (b) Shuttle Kiln, (c) Car Tunnel and (d) Push bat Tunnel in (Gujarat/January '93)

Sr. No.	Items	D.D. Kiln	Shuttle Kiln	Car Tunnel Kiln	
			Ceramic fibre lined	Ceramic fibre lined	Push bat Refractory lined
1	2	3	4	5	6
1. (a)	Kiln size	18′ dia	21 m^3 (with two cars)	0.6 x 0.9 x 21 mtr (WHL)	0.6 x 0.9 x 21 mtr (WHL)
(b)	Output	7 MT/ Cycle	2.5 MT/ cycle	1 MT/day	1 MT/day
(c)	No. of cycles per annum	36	192	-	-
2.	Investment on kiln	Rs. 6 lakhs	Rs. 10 lakhs	Rs. 15 lakhs	Rs. 15 lakhs
3.	Fuel	Steam coal	L.D.O.	L.D.O.	L.D.O.
4. (a)	Consumption of fuel (per MT of production)	1.60 MT	450 litre	320 ltr.	380 ltr.
(b)	Cost of fuel (considering total cost of production Rs. 8000)	Rs. 3200	Rs. 2990	Rs. 2080	Rs. 2470
5.	Duration of firing cycle				
	(a) Firing	36 hrs.	14 hrs.	14 hrs.	14 hrs.
	(b) Cooling	96 hrs.	10 hrs.	10 hrs.	10 hrs.
	(c) Total	132 hrs.	24 hrs.	24 hrs.	24 hrs.
6.	Quantity of kiln furniture (M.T.)	5	2	2	1.5
7.	Quality of production (figures in percentage)				
	(a) I & II class	20	60	70	70
	(b) III & IV class	65	35	25	25
	(c) Rejections	15	5	5	5

Source : From Field Study

Fire clay refractories

The manufacture of fire clay refractories in Gujarat predominently is in SSI Sector. There may be around 75 units in working condition. Almost all the units (with a few exceptions) are still working with conventional D.D. kilns. There is good scope for this industry to modernise by adopting shuttle kilns in place of D.D. kilns. Only three units (one in Ahmedabad, one in Kadi and one in Morbi) have installed new kilns.

Glazed Wall Tiles

This industry was confined to only large scale sector till the 1989 and has been working with

DESIGN CRITERIA

The primary factors to be considered when designing a fibre wall lining are as follows :

1) Maximum & operating temperatures

2) Desired cold face temperature

3) Gas velocity inside heater

4) Furnace atmosphere and type of fuel

Once the above basic information is available, one should note down the following important points which are normally not covered in the manufacture's leaflets.

1. The continuous service rating is quoted as general guide only. In certain applications e.g. expansion joints and one off use, the rating may be exceeded. In other most of the cases e.g. furnace/heater hot face lining, where high stability is required over long period, it is desirable to impose a lower (atleast by 100 deg.C) service limit.

2. Some fuels (e.g. heavy furnace oil) after combustion, create corrosive gases or ashes and although fibre is impervious to almost all of these corrosive materials, metallic anchoring system and furnace/duct castings are not. Sulphurous gases can permeate through the porous fibre layers, condensing on cold end of the anchoring stud and casing as Sulphurous acid and corrode the same. If mineral wool is used as the backing insulation, the sulphurous gases will destroy the binder and wool resulting in a powderous layer with no insulation.

The sulphurous acid problem can be cured by applying anti corrosion paint and by putting vapour barrier in form of metallic foil (aluminium or stainless steel depending on expected temperature).

Clean fuels like light oils, gas, electricity are free from such problems.

3. Ideal atmosphere for fibre lining is oxidising. Reducing atmosphere generally calls for higher grade material than one required as per temperature criteria. Presence of hydrogen in atmosphere increases the thermal conductivity of fibre lining, so much so that if hydrogen contents are more than 30%, fibre lining cannot be economically justified unless hard refractories are used on the hot face.

4. While designing fibre lining, we must consider temperature on the lining and not the product or charge temperature. This can be totally misleading e.g. in a heat treatment furnace charge temperature can be 700 Deg. C while walls close to burners will have temperature above 1000 Deg.C. This situation is particularly dangerous if there is a flame impingement on lining. The flame temperature are 1500 deg.C plus which fibre cannot withstand similarly gas velocities associated with flame can blow the fibre.

5. Ceramic fibre cannot take on mechanical damages. Areas prone to mechanical damage should preferably be lined with conventional refractories, e.g. skirt wall in bogie hearth furnace. Similarly, fibre cannot take load and hence cannot be used in areas like hearth.

There are two systems available for complete firbre lining :

1. Layered (wall paper) construction used upto 1050 deg.C.

Conclusions

Indigenous newer ceramic kilns such as shuttle and tunnel have already taken place in SSI sector of Gujarat State, discarding the age-old D.D. Kilns. The Ceramic industry in Gujarat is in the forefront towards modernisation. Thermally efficient and fuel saving shuttle kilns and tunnel kilns have been successfully installed for the manufacture of sanitarywares, L.T. Insulators, Crockery, Glazed Wall Tiles and Refractories in S.S.I. sector in the State. Indigenous ceramic fibre has been successfully employed as hot-face insulation in these kilns (excepting for the manufacture of refractories). Manufacture of various ceramic products including glazed wall tiles in the SSI sector is technically feasible and economically viable.

Small Industries Service Institute, Ahmedabad prepared project profiles (model schemes) on the manufacture of various ceramic products based on the newer kilns, for the guidance of prospective entrepreneurs.

since it is not likely to come loose in service.

Metallurgy of stud depends on the operating/maximum furnace temperature.

Material	Temperature Deg.C (Maximum Temperature)
S S 304 (18:8)	700
S S 310 (25:20)	1050
S S 330	1100
INCONEL 601	1200

The above temperatures are for general guide only and will vary with other conditions like furnace atmosphere.

Proper stud spacing is essential for a successful fibre lining. Stud patterns are determined by the with of hot face material (blanket/board/wetwrap), operating temperature, direction of gas flow and location. Backup joints should be staggered. Hot face joint can be only of the following two type :

(a) Compressed but joint used upto 900 Deg.C

(b) Overlap joints where the siders of the hot face blankets are overlapped by 50 to 75mm. This is most common pattern.

MODULAR CONSTRUCTION.

ANCHORED MODULES

In the layered construction the anchors are exposed to hot face temperature. Since these metallic anchors can withstand temperature only upto 1050-1200 deg.C while fibre as such, can be easily used upto 1300 deg.C the concept of embeded or hidden anchors same into lining design. Also ceramic fibre shrinks at temperature above 1000 deg.C. This shrinkage is negligible upto the temperature of 1100 deg.C and above this temperature one has to take care of shrinkage effect. This is achieved by providing compression (25%) in modular construction.

There are two types of anchoring system available. One with internal anchoring while the other one with external anchoring. In both these cases mettallic anchores are away from hot face and generally located below 800°C. Module anchoring system also provides combination of backup blanket lining and hot face modular lining. This not only helps in lowering the lining cost, but a backup blanket lining services safety lining in unlikely event of module failure.

In Ceramic Industry, particularly Tiles, Sanitaryware, Tableware units etc the temperatures encountered are between 1000 deg.C to 1300 deg.C The recommended Ceramic Fibre lining alongwith its expected thermal performances are as under :

Lining Pattern :	(A) Hot face :	200mm thk RTZ (1300 deg.C) Cerlock Modules
Backup :		25mm thk RT (1260 deg.C) 128 kg/m3 density blankets
	(B) Hot face :	

ii) GUJARAT

Presently, a little over 2.5 million cubic meters. per day of natural gas available is used mostly for fertilizer, power plants and industries. However, with the land fall point for South Basin gas fields being located near Surat and with recent high potential for natural gas being established at Gandhar and South/Mid Tapti gas fields, the availability scenario for natural gas has dramatically changed. For obvious reasons, the first priority for the use of natural gas in the State will be for the generation of power, fertilizer and core heavy industries will continue to take their share from the availibility and utilization balance by year 2000 A.D.

C. ADVANTAGE OF NATURAL GAS

i. Natural Gas has instant start/stop convenience. It enables conservation of precious petroleum fuels.

ii. Natural Gas has nosiseless and smokeless burner.

iii. Natural Gas gives out the most non-pollution flame.

iv. Natural Gas burners have standardized I.S.I. marked designs to obtain highest heat efficiencies and consequently result in optimum utilization of fuel.

v. Natural Gas is the safest modern fuel. Risk of accidents, explosions are minimized due to lower pressure in the distribution network, addition of odourants and other standard safety precautions.

vi. Natural Gas is an extremely cost effective fuel.

vii. Production distribution and use of natural gas do not imperil any natural habitat, wild life and maintains ecological balance.

viii. Promotion of natural gas as fuel will minimize the massive de- forestation.

D. NATURAL GAS FOR CERAMIC

GGCL prepared a very preliminary report to transport natural gas from Mehsana field to Surendranagar to be used mainly for ceramic industry. The report gave transportation cost for 50,000 M3 per day gas through pipeline of 140 km. form Mehsana to Surendranagar. This project also could not be initiated due to constraints of gas allocation. Two of the industries at Ankleshwar are using gas for ceramic products and advantages of natural gas as experienced by them (for manufacturing Ceramic Glaze Frits, Dyes, Fine Chemicals etc.) are given as under :

i. No carbon formation on nozzle of burner, giving complete combustion of gas drastically reducing the maintenance.

ii. As the gas is sulfur-free, the tiles are not affected by sulphur compound.

iii. If oil is used for glaze firing, the muffle is required for kiln, but in case of natural gas, no muffle is required.

iv. Natural gas forms homogenous mixture with combustion air.

(2) Furnace casing (particularly those on old furnaces) are rarely suitable for welding and require surface preparation through local grinding.

When anti-corrosive paint is to be applied to a furnace casing to guard against sulphuric acid attack manufacturer's recommendation of surface preparation must be followed.

(3) Stud welding can be either manual or automatic. Automatic stud welding is essential for large jobs and results in time and cost savings. stud welding equipment can be hired out for one time requirement.

(4) Installation of backup blankets consists simply of cutting the blanket to length and impalling it on studs. Joints should be staggered while installing the layers of the blanket to avoid heat leakage. When installing the roof sections the material can be supported using M S speed clips which are simply a push fit on stud.

(5) Installing hot face blanket is same like backup layer. Hot face layer should be as per the stud pattern.

(6) Blankets are held on to the studs by nuts, washers or cuplocks.

ERECTION PROCEDURE FOR CERWOOL CERAMIC FIBRE LINING.

(1) Clean the shell with wire brush.

(2) Do marking of anchor positions as per the drawing. Wherever discripancy between the drawing and actual site exists, consult supervisor for marking location. Marking should be in straight line to facilitate sliding of modules in place. Use chalk line for marking.

(3) Grind the shell at places where studs are to be welded. Use hand held surface grinder for this.

(4) Weld the studs with the help of stud welding gun. Use ferrules while stud welding. Welding with the help of electrodes (ASME SFA 5.4 E 309 or equivalent) also can be done.

(5) Apply dilute mortar on burner blocks and tube opening.

(6) Install the layers of blankets on anchor. Screw on clips on the studs. (Applicable in case you are using 25mm thk backup blanket lining to modules)

(7) Start installing moudles in the order given in the drawing. Slide modules channel into clips so that a good, rectangular pattern is maintained. Align all sides exactly.

(8) Check to see that the modules are square and in alignment. Adjust modules to get proper alignment. If some gaps exists, pack with U folds or strips as the cases may be. Cut out and remove bands and cardboard. pack again with strips where needed.

(9) Pound the lining from hot face with help of a 4" x 4" x 24" piece of lumber or a flat plate to fill up all gaps internally and give uniform appearance.

(10) List of tools required.

Roller Hearth	Bulk Fibre/Blanket	H&R JOHNSON, SPARTAK, BELL CERAMICS etc.
Kiln Cars	Blankiets/Boards/ Bulk	DECORA, GMB, GODVARI, KERA SINTERS, WS INSULATORS etc.

Initially there was some reservation regarding the application of ceramic fibre in Tunnel kilns because of its continuous operation. As the tunnel kiln once fired are in operation for months before its cooled-down. The savings on account of lower heat storage is negligible but one still get benefits because of the lower heat loss from the wall. It is interesting to note that one can drastically reduce the wall thickness and in turn can reduce the tunnel shell dimensions. This will also reduce the shell area from where the heat loss takes place. At the same time the cost of civil work (shell plate, foundation cost) can be reduced substantially. Since the weight of Ceramic fibre lining is less than 10% as that of the brick lining, one need not use thicker plate for casing. Even a 3mm thk casing plate can be used for the kiln construction.

is fibreized by either blowing or dropping the melt on high speed spinning discs. The manufacturers technology worldwide aims at increasing fibre length and increasing the yield of the fibre as compared to the unfibrized 'shot' which does not contribute to the thermal conductivity of the product.

Fibres are usually produced in two temperature grades, based on Al_2O_3, content. A recent addition is a ZrO_2 added Alumino Silicate FIBRE which helps to reduce shrinkage levels thereby rating the fibre for higher temperatures.

Continuous recommended Operating Temperatures	Al_2O_3	SiO_2	ZrO_2
1150°C	43-47%	53-57%	-
1250°C	52-56%	44-48%	-
1325°C	33-35%	47-50%	17-20%

These fibres are generally produced in bulk wool form and needled into blanket mats of various densities ranging from 64 to 160 kg/m^3. From the blankets converted products such as Modules (both anchored and veneering), Moist felt etc are made.

The other range of products made from Alumino Silicate fibres is the Vacuum formed shapes. Chopped ceramic fibre is mixed with other binders, made into a slurry and deposited on a porous tool to get the shape. The tool is inserted into the slurry and by applying vacuum through the tool, the slurry is sucked on to the tool, thus taking the shape of the tool. The commonest shape, mass produced is the board. Vacuum formed products are finished by drying the wet shape and machining down to required levels. These products are harder unlike the basic fibre blankets and find application where mechanical strength is also required. Vacuum formed products were first commercially introduced in India in early 1986.

The Key properties of fibre materials in making it a good insulation are :

(1) Light weight : 75% lighter than insulation fire brick and 90 to 95% lighter than Dense Refractory linings. For new furnace structural supports can be typically reduced by 40%, generally for a higher temperature 'K' value decreases with the increase in temperature.

(2) This is one of the major advantages of Ceramic fibres as the heat stored in Ceramic fibre lining is a very small percentage of the heat stored in conventional refractory lining.

(3) Thermal shock Resistance : Ceramic fibre linings are completely immune to thermal shock. Therefore pre-determined heat up and cool down cycles dictated by the furnace linings are eliminated.

(4) Thermal Efficiency : The low thermal conductivity of Ceramic fibre can be advantageously made use of by the lesser lining thickness and reduced furnace volume. The fast response of Ceramic fibre lining furnace also allows for more accurate control and uniform temperature distribution within the furnace.

(5) Resiliency : Being resilient it will withstand movement without cracking.

CORDIERITE KILN FURNITURE FOR CERAMIC INDUSTRIES

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INTRODUCTION

With more and more emphasis being put on faster and more economical methods of productions of consumer ceramics without loss of quality of the finished article, the cost of kiln furniture is one of the first things to come under strict scrutiny. For example, user industries such as manufacturers of ferrite components, tableware, sanitarywares, ceramic tiles, etc. are now using cordierite based kiln furniture due to its :

- low thermal expansion,
- reasonably high melting point, and
- light weight

After intensive R&D* efforts, we have developed Cordierite formulations that exhibit mechanical and thermal properties comparable to those of similar products from such leading Western manufacturers as M/s. ACME-MARLS, ANNAWERKE, DIAMOND & SPINX.

EXPERINMENTAL

Utilising indigenous raw materials, several cordierite formulations comparing of molochite grog and materials for insitu formation of cordierite phases were developed. Test prisms (25 x 25 x 1500 mm) were fabricated and their properties evaluated. Based on in-house data, field trials were also carried out at several customer locations to establish the usability of these cordierite formulations.

PROPERTIES OF GRINDWELL CORDIERITE (CDR 4050) REFRACTORIES) :

Table -1 and Figure-1 represents physical data for cordierite refractories manufactured by Grindwell. Also included are similar data for products from the above foreign manufacturers.

From the above data it may be noted that the properties of Grindwell's cordierite formulations are (nearly) matching those of imported products.

BENEFITS FROM USING CORDIERITE REFRACTORIES :

The following are the major benefits that can be derived by using cordierite refectories in ceramic industries :

Let us go on to see what we can do about furnaces operating at higher temperatures such as Billet heating furnaces.

For such high a temperature application, Ceramic fiber blended with pure Alumina fibers are used. These blended fibres shaped into blocks by Vacuum forming can stand 1200°C and beyond upto 1600°C depending upon the blend. These modules are made normally in one square foot blocks of 38-75mm thickness. They are simply pasted on the existing lining (this is called 'Veneering') in the furnace and a protective coating sprayed on the surface. This lead to

1. Decreasing the Thermal mass although the actual mass is increased by distributing higher temperature over a lower Ceramic Fibre mass.
2. Protecting the Refractory lining and thereby extending the life.

The density of these blocks are as low as 100-150 Kgs/m3 (6.2 - 9.4 pounds per cubic foot.) A typical case study in a Billet reheat furnace will enable the reader to understand the concept better.

Furnace	:	A steel Billet Reheat Furnace
Typical lining	:	230mm IS 8 115mm IFB (Hot Face) 75mm IFB (Cold Face) 30mm Slagwool
Veneering With	:	50mm of Ceramic Fibre Modules on the ISW 8 Bricks.

The Thermal Performance :

Before Veneering	After Veneering	
Hot Face Temperature	1280°C	1280°C
Cold Face Temperature	105°C	96°C
Heat Loss	866 Kcal/m2/hr	726 Kcal/m2/hr
Heat Storage (x 10^2)	174.8 Kcal/m2	162.1 Kcal/m2

FUEL SAVINGS : Based on the above figures, it is possible to compute down a fuel saving of about 60-70 liters for a 25m2 lining per shift.

Other High Temperature Ceramic Fibre Linings :

The latest developments aboard in High Temperature furnace linings are the anchored modules and the Board and Blanket system.

a) **Anchored Modules :** Performed blanket modules with various anchoring attachments are available for use upto 1300°C. These modules are fast to install and quick to repair.

b) **Board and Blanket system** : Hot Face insulation with high temperature Vacuumed Formed Boards followed by Blanket type of system is being tried out in various applications.

Having seen briefly what Ceramic fibre can do to make a furnace work better. One should always bear in mind that the usefulness of this material depends upon the furnace itself-its operating conditions, use and abuse, sophistication, cycling times, down time availability and of course the cost vs. benefit economics. The manufacturer of Ceramic Fibre will always be able to

INSTRUMENTATION FOR CERAMIC INDUSTRY

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- Shelter, drinking, cooking and sanitation
- Serves key industries by way of refractory goods
- Hi-Tech products like Space, Aircraft, Engines
- Insulation in Power Industries
- Metals substitute

INSTRUMENTATION USED IN

A (i) Analysis of raw materials

(ii) Analysis of finished goods

B (i) Relative humidity control in drier

(iii) Pressure monitoring & control in kiln

(iv) Atmospheric & Combustion monitoring & Control (Oxidizing & reducing)

(v) Safety (Detection of combustible & toxic gases)

BENEFITS

(i) More efficient use of manpower

(ii) Quality control & product improvement, consistency in final products & hence low rejection ratio

(iii) Economize production, avoid wastage of raw materials & energy.

(iv) Pollution control.

BENEFITS OF THE ABOVE PROPERTIES IN PRACTICE :

Greater Thermal Efficiency & Fuel Savings :

Due to lower thermal conductivity heat losses through the furnace walls are reduced. Wall thickness can usually by reduced as well.

Since heat storage is proportional to the mass of the lining material, heat stored in the lining is substantially reduced (heat stored in fibre lined furnaces are less than 10% in most of the cases.) This is a most important factor in cyclic operations allowing faster heat-up and cool-down which lead to greater productivity. Heating and colling time gets reduced to 50% in most cases. Lower heat storage in lining reduces the fuel consumption. Energy Savings in batch type operation (heat treatment furnaces) can be as high as 40% while in continuous operation it will be upto 15%.

Ease of Installation.

No need to rely on skilled labour. The flexible, easily cut material can be installed quickly, minimising wasteful plant down-time. Panel wise installation and shop fabrication is established practice for fibre lined reactor/furnaces due to light weight and stability.

Thermal Shock Resistance.

Most of the refractory lining failures are due to cracking or spalling as result of thermal shocks. There is no such possibility in case of fibre. It can also withstand vibrations due to its resilience.

Immediate startup.

No drying and curing cycle required. Heater can be fired immediately upon completion.

Ceramic fibre is available in various forms, grades and densities. The details are as under :

CERAMIC FIBRE PRODUCTS.

BULK FIBRE
1) HTZ (1425 Deg.C)
2) RTZ (1300 Deg.C)
3) RT (1260 Deg.C)
4) LT (1000 Deg.C)

BLANKETS
1) HTZ (1425 Deg. C)
2) RTZ (1300 Deg.C)
3) RT (1260 Deg.C)
4) LT (1000 Deg.C)

MODULES
1) HTZ (1425 Deg.C)
2) RTZ (1300 Deg.C)
3) RT (1260 Deg.C)
a) ANCHORED
b) VENEERED

BOARD/SHAPES
1) THERMOTECT 80 (1600 Deg.C)
2) HTZ (1425 Deg.C)
3) RTZ (1300 Deg.C)
4) RT (1260 Deg.C)
5) A (1260 Deg.C)
6) LT (1000 Deg.C)

SPECIALITIES
1) WETWRAP
2) CEMENT
3) COATING
4) VENEER MORTAR
5) MOULDABLE F/MOULDABLE JOINT PAX
6) ROPE
7) HOT STOP

DIFFERENT PROPERTIES OF CLAYS

Sl. No.	Properties	Rajasthan Clay (Raw)	Washed Than Clay	Washed Shanthalpur Clay
				(as received)
1.	PARTICLE SIZE	%	%	%
	a) Above 10 μ	11 ± 2	18.0	19.7
	b) Above 2 μ	34 ± 2	47.0	57.5
2.	PHYTSICAL			
	a) Residue over 45 μ	1.5	1.23	1.11
	b) Drying Shrinkage	5 ± 1%	5.6	8.22
	c) Firing Shrinkage	10 ± 1%	6.50	10.06
	d) Water Absorption	0.5%	9.80	Nil
	e) Fired Test piece condition	Free from iron specks	Light cream white color	Light grey color
	f) Green Strength Kg/CM^2	70 ± 20	61.60	106.2
3.	CHEMICAL COMPOSITION			
	a) % SiO_2	58.0 ± 2	59.65	64.60
	b)	% Al_2O_3	28.0 ± 2	23.96
	c) % Fe_2O_3	2	0.05	1.02
	d) % TiO_2	1	0.25	0.35
	e) % CaO	1	0.84	0.29
	f) % MgO	1	0.20	0.20
	g) % KNaO	1.5	0.88	0.54
	h) % LOI	11.0 ± 1.5	14.13	8.87

2. Modular construction from 1050 deg.C. to 1300 deg.C.

Layered Fibre Wall Construction.

The layers of blankets are installed on metallic studs which are welded to the shell. In this case, options are as follows :

(a) Hot face lining material - Normally high density blanket (128 kg/m3) are used and grade is decided by peak operating temperature. If inside gas velocities are likely to be more than 15M/Sec, one will have to use wetwrap (blankets soaked in rigidiser solution and squeezed.) For higher velocities and for requirement of rigid surface, vacuum formed board may have to be used.

(b) Backup insulation - To achieve the overall economies back up blanket layers are of lower densities, either 96 kg/m3 or 64 kg/m3, grade of the material is decided by interface temperature on the layer.

(c) Lining thickness - Overall lining thickness and the thickness of each of the components is determined by thermal calculations for which ready computer programmes are available. Computing service, to potential customers, is offered free of charge. The parameters entered into the computer are as follows :

1) Hot face temperature
2) Ambient temperature
3) Outside wind velocity
4) Casing surface position
5) Lining materials
6) Thickness of each material

Computer output for that particular construction consist of the following :

1) Cold face (casing) temperature
2) Heat loss to surrounding through lining
3) Heat storage
4) Inter face temperature of the lining

As a practice following thickness are commonly used :

HOT FACE TEMPERATURE	LINING THICKNESS	CONFIGURATION
upto 400 Deg.C	100 MM	25mm RT 128 kg/m3 75mm LT 64 kg/m3
400 to 700 Deg.C	150 MM	50mm RT 128 kg/m3 100 mm LT 64 kg/m3
700 to 1000 Deg.C	200 MM	50 mm RT 128 kg/m3 50mm RT 96 kg/m3 100 mm LT 64 kg/m3

(d) Stud Material & Pattern - Generally twist-o-lock stud is preferred since it is quicker to install and is the only available stud for use with the cuplock. In special applications e.g. if the lining is subject to vibration, excessive movement or the same stud is also supporting metallic sheet, heating element support, the threaded variety of stud with washer and nut performs better

ANNEXURE - IV

X-RAY DIFFRACTION PATTERNS

Mineralogy	:	
Rajasthan Clay	:	Kaolinite Quartz Illite Traces of smecite
Santhalpur Clay	:	Kaolinite Quartz Illite Traces of smectite

The XRD patterns recorded under identical conditions show that Kaolinite content is almost same in both cases and quartz is more in Santhalpur clay compared to that of Rajasthan Clay.

The reflections in the region 19 deg-22 deg 2 indicate tha the Santhalpur clay is an ordered one with a higher degree of crystallinity as indicated by a well resolved triplet and the Rajasthan Clay is a disordered one as indicated by a doublet.

No comments can be made on Illite and smectite as the quantity observed is very small.

ANNEXURE - V

ELECTRON MICROGRAPHS

The electron micrographs of the Rajasthan and Santhalpur Clay samples show that the particle size is comparable although there is a marked change in the particle morphology and fabric.

Rajasthan Clay shows (both in washed and unwashed form) no definate morphology and the particle allignment shows preferred orientation during its formation (probably a sedimentary feature).

Santhalpur clay shows some degree of well defined plate morphology (psuedohexagonal ?) suggestive of higher degree of ordering (inferred in the XRD patterns also).

Chalk line, tape measure, surface grinder, stud welding gun or standard welding set, hammer, pliers, knife, 4" x 4" x 24" wooden log or wooden plate, felt marking pen.

(C) INSTALLATION OF VENEER MODULES

(1) Prepare and clean the existing refractory. An additional optional steps which may be utilized is to spray coat the existing refractory with a thin mortar layer.

Note : In the cases where modules are being installed over existing IFB lining spray coating the existing refractory is mandatory.

(2) Apply a thin layer of veneer mortar on to one side of the module working it back and forth so that there is good mortar pentration into the module.

(3) Apply a second layer of mortar, approx. 1/4" thk and spread it evenly over the module. Approximate quantity of mortar required is 1 kg./sq.ft.

(4) Install module into position by applying firm but equal pressure to all sides of the modules.

(5) Allow the veneer mortar to set for 24 hours before applying veneer coat. The minimum mortar setting time is 8 hours, but it is strongly recommended that the 24 hours setting time is given whenever possible.

(6) Spray the installed modules with veneer coat. The quantity of coating utilized is 0.3 to 0.4 kg per sq.ft.

APPLICATION IN CERAMIC INDUSTRY.

In India there are several kilns have now been lined with Ceramic Fibre Products. In Saurashtra District (Gujarat), particularly in Thangad area, there are more than hundred kilns, both shuttle & Tunnel have now lined with Cerwool Ceramic Fibre Products.

More number of people are now switching over from Brick lining to Ceramic Fibre lining because of the substantial fuel savings and shorter turn-around period.

The brief details of applications, product used alongwith the important customers who are using Ceramic fibre lined kilns are as under :

Tunnel kiln	Blanket/Board/ Module lining	H&R JOHNSON, DECORA CERAMICS (TILES), GMB CERAMICS, GODAVARI CERAMICS, HINDUSTAN SANITARWARE (SANITARYWARE) FORMOST CERAMICS etc.
Shuttle kiln	Modules/Veneer Modules	MADHUSUDAN CERAMICS (TILES & SANITARWARE), APEX CERAMICS, BHEL - BANGALORE (INSULATOR) etc.

- temperature stability upto 1300°C.
- low thermal expansion.
- excellent thermal shock resistance.
- no shrinkage or growth during firing (i.e. dimensional stability)
- low weight : hence, high product/kiln furniture weight ratio.
- low mass kiln furniture ; hence, fuel economy.
- ability to withstand fast firing cycles.

From the above explanations it may be concluded that cordierite refractories having excellent physical properties have been developed for use in the manufacture of tableware, ceramic tiles, sanitarywares, ferrite components, etc.

GRINDWELL'S CORDIERITE PRODUCT RANGE :

Cordierite (CDR 4050), is available in the following shapes :

- Batts
- Supports • Posts
- Saggars • trays
- Cassettes.

Key words : Cordierite, Thermal Expansion, Tableware, Ceramic Tiles, Sanitarywares, Ferrite.

TABLE - 1 : TYPICAL PROPERTIES OF CORDIERITE REFRACTORIES

PROPERTY	GNO	ACME-MARLS	ANNAWERKE	DIAMOND	SPHINX
B.D. (g/cc)	1.95-2.0	1.91-1.95	1.95	1.9-2.1	1.85-1.95
A.P. (%)	20-24	28-30	27	25-28	25-30
M.O.R. (kg/cm2)					
R.T.	100-120	170-200	153	170-210	130-180
1250°C	100-140	100-120	60	100-120	110-140
C.T.E. ($x10^{-6}$/0C)	2.8-3.0	2.8-3.1	4.00	2.8-3.0	2.0-2.3

ZIRCON SAND AND ITS APPLICATION IN CERAMIC INDUSTRY

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Zircon, an ore of Zirconium oxide metal occurs along with other heavy minerals like ilmenite, ruitle, garent, sillimanite, monazite and kyanite in the beach sand deposits. All the commercial production of Zircon Comes from these alluvial deposits.

Zircon (ZrSi04) contains 67.2% zirconia (Zr02), 32.8% silica (Si02) and traces of iron (Fe203). It crystallises in the tetragonal crystal system and is characterised by the prevailing square pyramid or square prism, also by its adamantine luster hardness (7.5 in MOU's scale) high specific gravity (4.68 - 4.70) and infusibility.

The major zircon producing countries in world are Australia, South Africa, U.S.A., and U.S.S.R. The other minor zircon producing countries are Brazil, China, Indian, Malasia, Thailand, Sierra Leone and Sri Lanka. The world production of zircon in 1990 was about 1.09 million tonnes and India's contribution to this was about 17,000 tonnes (1.6%).

In India IRE is the major, perphas the only producer of zircon from beach sand heavy minerals. IRE produces three grades of zircon from their mines at Chavara (Kerala), Manavalakurichi (Tamil Nadu) and Chatrapur (Orissa) and they are marked by the brand names 'Q' grade, 'MK' grade and 'OR' grade respecctively. The typical analysis of IRE zircon grades are shown below :

Grade	Zr02+HF02	Si02	Ti02	Fe203
Q	65.10	32.40	0.30	0.10
MK	65.30	32.50	0.30	0.09
OR	65.00	31.50	0.30	0.40

Typical sieve analysis :

Mesh	Cumulative wt% retained		
Tyler screen	'Q' grade	'MK' grade	'QR' grade
35	0.1-0.2	0.0-0.3	-
48	0.1-3.5	0.1-2.5	-
65	23.0-38.0	7.5-20.0	14.5
100	76.5-89.5	41.0-65.5	35.5
200	100	100	99.5
250	-	-	100.0

INVESTIGATION STUDY ON CLAYS FOR ELECTROPORCELAIN INSULATOR MANUFACTURING

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The Electroporcelain Division of BHEL, Bangalore is engaged in the manufacture of high tension electroporcelain insulators. Apart from other types of clays, a particular clay from Rajasthan is also used as one of the raw materials. In this clay, there were problems of inconsistent supplies, quality and cost escalation. Hence, a project was initiated to see the possibility of finding an alternative materials.

Clay samples from different places were procured which included from main origons of Gujarat also. The properties of these samples were compared with that of clay from Rajasthan. It was found that these clays needed further benefication which were carried out. The samples were again tested after the necessary benefication. Samples of insulators were also made by replacing Gujarat Clay Santhalpur Clay) for study of the properties of Rajasthan Clay with Gujarat Clay. The different properties of Rajasthan clay and the clays of Gujarat before and after benefication and also the fired properties of the insulators (comparative) by using Santhalpur clay in place of Rajasthan Clay are enclosed in the Annexure.

As could be seen from Annexure-I, the particle size of Than and Santhalpur is high compared to that of Rajasthan clay so also the residue on 45 micron sieve.

After beneficiation, the improvement in particle size in respect of the above two clay and residue and slight increase in the green strength is also observed as per Annexure-II.

In the Atterberg's plasticity index data in respect of bodies prepared, it is observed that the body with santhalpur clay has shown higher value compared to that of the body combination with that of Rajasthan clay.

This is evident as the green strength of beneficiated santhalpur clay is much higher than that of Rajasthan clay. The workability of santhalpur clay body was better and so also while shaping of the insulator samples.

The Modules of rupture, Thermal bonding, Thermal expansion and X- ray diffraction values as could be seen are comparable which indicate higher E.M.S. values of the insulator. This data could be seen from Annexure-VII.

Conclusion :

Based on the exhaustive comparative study, it may be concluded that Santhalpur clay can replace Rajasthan clay by 50% in the insulator body after the beneficiation. It is worth mentioning that both the Gujarat clays samples were received in washed condition which needed further beneficiation for improvement of properties. However, some more studies may be required about the quantum of deposits in Gujarat belt.

industrial processes and other technologies notably for valves, metal processing, mining and minerals processing. PSZ has great promise as a biomedical material. Tiny PSZ dental brackets are now available as long lasting in conspicuous supports for dental braces.

Zircon demand in the ceramics industry will derive benefit from such techological developments as fast-firing kilns as well as increased consuption of floor and wall tiles.

Zirconia powders are fining increasing use as pure or mixed addition to ceramic composition in order to enhance material strength. Typical application will include use in high performance cutting tools and in plasma coating technology which is being applied for coating glass, plastics and metals.

The advancement in Ceramic technology for increased usage with no possible substitutes to challenge provide a commanding position for zircon in Ceramic industry.

ANNEXURE - VI

PLASTCITY INDEX DATA OF BODIES

Plasticity Index	Routine Body (with Rajasthan Clay)	Body with 1	Santhalpur Clay 1
Liquid Limit	42	50	42
Plastic Limit	29	32	30
Atterburg Number	13	18.	12

Routine body : with 100% Rajasthan Clay

Body Composition with Santhalpur Clay :

1. With 50% Santhalpur Clay
2. With 100% Santhalpur Clay

ANNEXURE - VII

FIRED STAGE DATA OF INSULATOR SAMPLES

Properties		CTI-I	CTI-II	ROUTINE-SB	
1.	Modulus of Rupture (Kgs/Cm2)				
	(a) Glazed	1160	1002	1050-1100	
	(b) Unglazed	1054	988	960-1000	
2.	Thermal bending (Log K)				
	(a) Top	6.24	6.15	6.27	
	(b) Bottom	6.22	6.09	6.22	
3.	Porosity On Insulator Sample	Non porous	Non porous	Non porous	
4.	% Thermal Expansion				
	R3	250 C	0.192	0.138	0.220
		650 C	0.494	0.384	0.484
	R1	250 C	0.160	- -	
		650 C	0.472	- -	
5.	X-ray Analysis				
	R1	Quartz	37	4038	
		Cristobalite	21	1 35	
	R3	Quartz	38	3640	
		Cristobalite	28	4 32	

DEVELOPMENT OF CORDIERITE KILN FURNITURE FOR CERAMIC INDUSTRY

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ABSTRACT

Ceramic industry involved in manufacture of pottery, sanitarywares, low/high tension insulators, electronic ceramics, glazed tiles etc. require cost effective high performance kiln furniture for economical production of wares. Since the impact of fuel crisis in 1970's, the industry has adopted several measures to conserve fuel including use of Cordierite kiln Furniture and adopting low thermal kiln car design. The paper outlines the development work undertaken to manufacture cordierite kiln furniture using indigenous rawmaterials and upgraded production facilities at a new location. Field trial results achieved in various kilns with setter tiles and the design and construction of LTM kiln cars are reviewed. Setter tiles have given satisfactory performance in many kilns and LTM cars in one plant have performed well since 1986 with minimum maintenance. Use of LTM car design with cordierite tiles, posts and accessories has yielded fuel savings of 10%.

INTRODUCTION

Ceramic based industries manufacturing pottery, sanitarywares, low/high tension insulators, electronic ceramics, glazed tiles and high alumina bodies require high performance kiln furniture for setting their wares for firing in periodic or tunnel kilns. These industries use saggars, setter tiles, sliding plates, posts, girders, baffles etc. as kiln furniture.

Since the impact of fuel crisis in 1970's fuel cost which forms a significant percentage of the total manufacturing cost has forced these industries to cut costs including fuel by various methods. For example, the cost structure of an Italian floor/wall tiles manufacturers is given in Table 1. Such data a are not available from our ceramic industries for valid comparisons. The important point to note is that 35% of cost is attributed to energy usage. The ceramic industry all over the world responded with various methods to cut costs by adopting :

- Fast firing cycles
- Single vs Double firing
- Reduction in kiln furniture weight : higher payload.
- Use of ceramic fiber for kiln lining
- Switch from tunnel kilns to shuttle/Roller kilns
- Reduction in rejects
- Use of alternate raw materials.
- Process change
- Automation/Robots
- Low thermal mass kiln cars
- Heat recovery by recuperation etc.

The production capacities of IRE Plants are :

Chavara	..	12,000 tonnes/annum
Manavalakurichi	..	6,000 tonnes/annum
Chatrapur	..	2,000 tonnes/annum

IRE is also pulverising zircon to -325 mesh size using a fluid energy mill at their factory at Chavara. This product is marketed by the trade name 'ZIRFLOUR' which has superior quality compared to other grinding systems, being free from media and external contaminations.

USES

The major uses of zircon are in refractories, ceramics and foundries. The world consumption of zircon in various industries are :

a)	Refractories	35%
b)	Ceramics	25%
c)	Foundries	21%
d)	Others	19%
	Abrasives	
	Glass	
	Zirconium compounds	
	Zirconium metal & alloys	

Zircon is used either in the form of sand or as milled (-200 or - 325 mesh) or micronised (1, 5 or 10 microns) powders. For the uses in refractories, foundries and abrasives, the quality is not very critical so that standard grades are used. But for ceramic opacifiers, special refractories and production of zirconium metal or chemicals the higher quality premium grade is preferred.

Ceramic industry which is a traditional bastion for zircon is the second major market. In Ceramic industry finely ground material is applied to glazes and its high refractive index is utilised to good effect for opacification purposes. Ceramics is possbily the only area where the traditional consideration of iron and titamium impurities is still of paramound importance. Most consumers require the raw sand to be low in both of these impurities to ensure whiteness in glazes, although companies can actually adjust the relative levels in order to achieve staining effects in firing where necessary. It is also preferrable to use material that has not required prior leaching because residual acid leads to wear and tear in the attritioning circuit.

The progressive increased demand for zircon in Ceramic industry in Europe and Japan during the last decade has resulted in exorbitant rise in zircon price and demand was such to create spot prices for zircon inspite of increased production.

Partially stabilised zirconia (PSZ) ceramics was developed in the early 1970s by material scientists at the commonwealth Scientific and Industrial Research Organisation (CSIRO). PSZ's extra oridinary resistance to wear is being applied to increasing numbers of

CORDIERITE KILN FURNITURE

Modern cordierite kiln furniture is essentially based on cordierite phase 2 Mg0.2 Al2O3.5 Si02 in combination with mullite phase. Cordierite phase occurs as a rare mineral in nature. It constitutes the phase found in the triaxial diagram of Mg0-A1203- Si02 bounded by the lines joining five eutectic points ranging from 1345- 1460°C as shown in Figure 1. Cordierite shows polymorphism, three forms having been recognized. Of these the alpha-form is the stable high-temperature form and the only one normally found in Nature or obtained in cordierite products. Beta and gama CORDIERITE can form only under special conditions.

The development of cordierite in a ceramic body is not achieved by using raw materials whose chemical composition sums up to that of cordierite. Two conflicting factors affect the results. One is the fact that equilibrium is rarely reached during a ceramic firing. The other is the proximity of the various eutectic points so that if equilibrium is approached only small deviations from the correct composition would produce melting and/or unwanted phases. Bodies of high cordierite content invariably have a short firing range. Underfiring failsto develop the cordierite and overfiring results in its deterioration into forsterite and mullite, both with much higher expansion coefficients.

The range of body compositions within the system Mg0-A1203-Si02 to give useful cordierite body is

Mg0 = 2.60 - 13.80% wt.

A1203 = 25.50 - 38.8 % wt.

Si02 = 51.40 - 64.9 % wt.

The most favored is : Mg0 = 13.8 %

A1203 = 34.8 %

Si02 = 51.4% which gives a molecular ratio of 2 Mg0.2 Al2O3 Si02. The most commonly used raw materials for development of cordierite bond in kiln furniture are clay, talc and alumina. Presence of free quartz in the raw materials will adversely affect the thermal expansion property of the body. In addition, care should be exercised in selecting the grog for designing the cordierite refractory. Most manufacturers use sintered aggregates containing mullite phase and the commercial grade cordierite bodies are composites of mullite and cordierite phases. Lowest thermal expansion is achieved with bodies containing higher cordierite fraction while the more refractory compositions result when mullite content is on its higher side. The fluxing impurities carried over from the starting raw materials play key roles in high temperature performance of the product. Cordierite kiln furniture parts tends to become pyroplastic above 1250°C and undergo creep/sagging in service. In fact, failure occurs primarily due to excessive creep. Setter tiles are most prone to deformation in service due to temperature or heavy loading. Therefore, the body design must ensure that deformation due to creep occurs at a higher temperature and hence selection of raw materials is extremely important since the basic raw materials are natural minerals except alumina. Development of cordierite products comparable to imported with indigenous raw materials poses a challenge to the technologist.

are built with the design recommendations of the manufacturer of kiln furniture systems so that maximum stability is assured during operations. The use of cordierite components and kiln furniture, however, limits the maximum temperature to 1300°C which is the upper limit for all types of ceramic ware firing. Silicon carbide, mullite kiln furniture are used for higher temperature operations exceeding 1300°C. Figure 3 shows the conventional kiln car compared to a modern LTM kiln car. LTM car was constructed with cordierite posts batts and setter tiles. The design ensures that the load is directly rests on the base of the car. Unlike the conventional kiln car construction, there is no need for wad clay or mortar for cementing the tiles and posts and leveling the decks. The design allows quick repairs when the occasion needs it. Different types of posts such as tabular, I beam, 3-piece system with caps etc. are used in different arrangements. Cordierite tiles have the tendency to deform and sag after several cycles and they need 'turning' to extend their service life. The LTM car design allows this turning without need for dismanting and reassembly of the super structure.

The LTM kiln cars have been designed and used in a tunnel kiln firing heavy loads of vitrified grinding wheels since 1986. These 57 cars have been operating till date (for 6 years) without major problem except periodic maintenance. The design ensures bottom sealing so that no heat is lost through gaps between the kiln cars. No problem of kiln car collapse or blockage of tunnel was encountered since starting in 1986.

The benefit derived are as follows :

- Reduction in kiln car weight by 40%.

- Fuel savings of 10% achieved.

- Faster firing cycle adopted.

- Low maintenance of kiln car and structurals.

- Use of cordierite kiln furniture at lower cost compared to SiC kiln furniture used before change.

CONCLUSIONS

The ceramic industry manufacturing pottery, sanitarywares, electrical insulators, grinding wheels and other products have adopted several measures to conserve fuel and increase the output from the kilns. Cordierite kiln furniture and LTM kiln cars are increasingly used to achieve these objectives. Cordierite kiln furniture has been developed by M/s. Carorundum Universal Ltd., Madras which has performed satisfactorily in many kilns. A manufacturing facility at a new location has been commissioned to produce cordierite products. The LTM kiln cars designed and constructed by CUMI have been performing satisfactorily since 1986 in one of their tunnel kilns firing grinding wheels with minimum maintenance. The fuel savings achieved by adopting cordierite kiln furniture and LTM cars is 10%. These concepts if adopted on a large scale by the Indian Ceramic Industry, considerable fuel savings and higher productivity can be effected.

The author thanks the Management of M/s. Carborundum Universal Ltd. for presenting this paper. My thanks are due to colleagues in Technical, Manufacturing and Sales Departments for their support.

TABLE NO. 3

FIELD TRIAL RESULTS

INDUSTRY	SIZE	KILN TYPE	KILN CYCLE	LIFT CYCLES	SERVICE TEMP.0C
POTTERY	17" 1/2 X 14" 1/2 X 5/8"	ELECTRIC TUNNEL	7 HRS. COLD-TO-COLD	500	1100
SANITARY WARES	400 X 334 X 30 24" X 5" X 1"	OIL FIRED TUNNEL OIL FIRED TUNNEL	22 HRS. 24 HRS.	100 100	1220-1250 1220-1250
ELCTRO CERAMICS	15 X 12 X 1/2"	FERRITES		100	1200
ABRASIVE GRINDING WHEELS	26 X 14 1/2 X 1.5/8" 15 X 12 X 1/2"	OIL FIRED TUNNEL	72 HRS.	50 100	1300

SIZES AVAILABLE

17 1/2 X 14 1/2 X 5/8"

17 1/2 X 11 1/2 X 5/8"

20 1/2 X 17 1/2 X 1.1/8"

15 X 15 X 1

400 X 337 X 30

Any Other Size

26 x 14 1/2 x 1.5/8"

15 x 12 x 1/2"

These changes in the manufacturing processes have placed a premium on the quality and durability of kiln furniture. The traditional clay bonded refectories are no longer suitable for cost effective performance.

Silicon carbide kiln furniture has been in use for more than 100 years in the ceramic industry. However, the high cost of synthetically made SiC products are no longer attractive for severe applications. The trend has been to use cordierite products in many plants. In the last 10 years cordierite setter tiles and posts have been used extensively by the Indian Ceramic Industry. The requirements have been met by imports and locally manufactured products. The paper attempts to outline the R&D work undertaken by Carborundum Universal Ltd. to indigenously manufacture Cordierite kiln furniture and design and build-up of low thermal mass kiln cars.

CHARACTERISTICS OF IDEAL MATERIAL FOR KILN FURNITURE

Since the kiln furniture is reused over tens of cycles in periodic or tunnel kiln operation, it is subjected to high temperature, thermal shock due to rapid change in temperature, abrasion, corrosion by kiln atmosphere and erosion. Thus an ideal material should have the following properties :

- High cold and hot strength
- Creep resistance
- Refractoriness
- Chemical inertness
- High thermal conductivity
- Low thermal expansion
- Phase stability
- Superior thermal shock resistance
- Low cost and high performance.

In practice, none of the known refractories meet all the requirements listed above. By and large silicon carbide and CORDIERITE meet the demands to a great extent. Silicon Carbide, however, has the tendency to oxidise and convert to cristobalite depending on the kiln atmpshphere and the life is controlled by the rate of oxidation. Besides its high cost, it is not suitable for rapid firing cycles (7 hours). Recent advances have overcome some of these deficiencies by development of silicon nitride bonded SiC and recrystablised silicon carbide. But these new products are more expensive than the traditional oxide- bonded SiC kiln furniture.

Where thermal shock resistance, low to moderate load conditions exist in the kiln operations, cordierite kiln furniture are increasingly used. Cordierite kiln furniture have proved to be suitable for fast firing kilns and in many Indian kilns its performance has been superior compared to oxide-bonded silicon carbide. Apart from the tendency of cordierite products to creep under load, they have a maximum service temperature limit of 1300C. Another aspect of cordierite is its low resistance to crack propagation compared to silicon carbide products.

GLAZES AND FRITS FOR WHITEWARE INDUSTRY

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Glazes and frits are important in whitewares and particularly so far tableware, Glaze contains ingredients of two distinct types in different proportions of refractory materials such as, Feldspar, Silica and Chinaclays and fluxes such such as

Soda Potash Floraspar and borax. Different combinations of these materials and different temperatures at which they are fired give a wide range texture and quality. The glaze must bond with the ware and its co-efficient of expansion must be sufficiently close to that of the ware to avoid defects such as "Crazing" and "Peeling". Earthenware should be glazed between 1050 to 1100C stoneware between 1250 and 1300C.

Hard glazes which are applied on porcelain stonewares generally melt above 1200C. They contain much alumina and silica with alkalies, lime or magnesia as bases.

Medium Glazes are used on fine earthware melt between 1050C and 1150C. These glazes contain less alumina and silica, some portion of the letter being replaced by boric oxide, lead oxide is used to power down the melting point.

Soft glazes are used on low temperatures majolica wares and melt at above 900C. These glazes, generally contain the alkalies and leadoxide with small amount of alumina and silica to form and easily melting transparent glaze.

The method of preparation and application of glazes is one of their determining factors. The constituents are finely ground in aqeous suspension which is then applied to dry raw or biscuited body. It is therefore necessary that the raw materials. Put in mill are water insoluble and this may entail their previous treatment by fritting. The glazed body is next dried when the glaze must adhere regularly otherwise crawling may occur. It is then fired, when the glaze mixture must fuse and becomes homogenous without becoming so fluid that is begins to flow off the vertical portion of the article.

The finished glaze must be hard, smooth and glossy (except matt etc. glazes) This is not only for the visual effect, a smooth surface is more resistant to chemical and physical attack it is less likely to fracture. By applying a glaze of slightly lower co-efficient of expansion than that of the body the cooled glaze is brought into slight compression and the mechanical strength of piece is improved.

A good glazes have following desired properties :

1. Feasibility must be such that maximum liquid glaze is formed at the desired maturing temperature.

2. Viscosity should be moderate at peak firing temperature so that surfaces even out but no overall flow occurs down inclined or vertical surfaces.

3. Surface tension should be low to avoid crawlings.

4. Volatisation of glaze components during firing should be minimised.

5. Reaction with the body should be moderate to give good fit without too much change in composition of either glaze or body.

6. Absorption into the body of glaze constituents or entecties formed during firing should not occur.

7. Devitrification should not occur in transparent glazes.

8. expansion co-efficient and young's modules of elasticity should relate to those of body in such a way that maximum strength is achieved.

9. Homogeneity , smoothness and hardness to resist abrasion scratching etc.

10. Chemical durability.

11. Colour for aesthetic or thermal reasons.

12. Electrical properties e.g. low power factor.

The general conventional form of expressing a glaze composition is RO, R203, Ro2 called the molecular formula. Here RO stands for the oxides alkaline earths and the divalent metal such as lead zinc etc. R203 represents alumina and some time of ferric oxide. R02 stands for silica and often boric oxide. The total oxides under RO is made unity and the other oxides are modified accordingly. This method of representing the composition of glaze helps to a great extent in comparing and controlling their properties.

Various defects arise during the manufacture of glaze pottery, some of which are seen to disappear before the real cause of their origin could be ascertained amongst others the following are the most important.

Crazing and peeling: If the contraction of the glaze during cooling is greater than body, the strain or tension thus set up causes the glaze to develop hair like fine cracks, throughout the glazed surface of the wares. This defects of the glazed ware is called the crazing.

If on the other hand the contraction of the glaze is less than that of the body the glaze will be under a compression and is likely to detach from the body specially at the edges. The compressive force may sometimes be so great as to break the body into small piece. This defects which is opposite to crazing is known as peeling.

Several raw materials were systematically evaluated for manufacture of cordierite products by M/S. CUMI over the years. The manufacturing facilities were upgraded to mould and fire cordierite bodies with minimum loss in view of the narrow firing range of cordierite as mentioned earlier. High losses which is normal for cordierite were reduced to acceptable levels. Expertise and capabilities to manufacture large/thick tiles perforated setter tiles, tabular and slotted posts, accessories for construction for low thermal mass (LTM) kiln cars, complex shapes such as trays/saggers etc. were developed in-house over the past 5 years. The improved facilities plus better controlled kilns have been installed at CUMI's Ranipet plant exclusively for manufacture of cordierite products suitable for use by the Indian ceramic industry. Product upgrading, customer service and other activities to match the imported products are continuing.

The physico-chemical properties of two types of cordierite products are given in Table 2. Cumirite I is suitable for higher temperature applications. Cumirite II has performed satisfactorily in many kiln upto 1280°C. Comparative data on imported cordierite products are also shown in Table 2. The field trial results are shown in Table 3. where the various sizes which can be manufactured are also listed. Figure 2 shows the various shapes and sizes of setter tiles and posts which are currently manufactured on routine basis.

LOW THERMAL MASS KILN CAR (LTM Car)

A moving car in a tunnel kiln, or car used in a shuttle kiln soaks up and carries away considerable amount of sensible heat which is dissipated to the atmposphere during unloading and reloading period. It once again gets heated up when it enters the heating zone of the kiln. Hence, by reducing the thermal mass of the kiln car the heat storage capacity can be drastically reduced which in turn, can reduce the fuel usage. With 50% fuel efficiency every k.Cal, a car removes from the kiln requires two k.Cal heat input. By adopting the low thermal mass kiln car construction it is feasible to reduce the fuel consumption by 6.25%. The general requirement of a kiln car for use in intermittent and tunnel kilns are that it should be strong and stable enough to support the pay load and also be thermally efficient. The conventional kiln car design using bricks or castables (strong enough to support the wares) by nature act as massive heat sinks.

A typical convention kiln car uses the following materials for construction.

- Dense bricks of high Alumina type, sillimanite, keynote, mullite etc.
- Dense castable blocks, and
- Deck slabs of silicon carbide, mullite, sillimanite etc.

A modern LTM kiln car uses :

- Light weight castbles/aggregates
- Ceramic fiber in the form of wool, boards, modules etc.
- Kiln furniture (slabs, posts, baffle plates etc.) predominantly in cordierite composition and
- Easy to assemble and dismantle super structure system.

The LTM kiln cars either use firm structure using the above materials or interlocking structures without cementing so that shelves can be changed to accommodate any size of wore. These systems

The greater cost is balanced by the case of application and firing.

Boric acid frits: As basic oxide and most borates are soluble in water, boron must be introduced as frit. A typical lead free frit is shown below:

0.69-Cao		2.17 Sio2
0.19-Na2o	0.37A1203	1.16B203
0.12-K2o		

Lead containing frits: For reasons of health, lead is usually introduced into commercial glaze as frit. The simplest frit is the lead by silicate Pbo 2si02 which is relatively insoluble in water. A more complete frit may also contains alkalies and aluminas as:

0.94-Pbo		
0.03-Na2o	0.07 A12o3	1.23 Si02
0.03-K20		

Frit with both lead and boric oxide - These frits are often used in low temperature glaze. Typical composition is :

0.53 pbo		
0.10 Na2o	0.12 A12o3	2.70 Sio2
0.07 K2o		0.69 B2o3
0.30 cao		

A great effort has been made to eliminate the lead in glaze both here and abroad. However, it is very difficult to retain the ability to wet (flow over bare spots) even over a smooth surface or to have a high brilliance without lead. Orlowski and Marquis' report on some excellent leadless glaze for dinner ware, while Danielson and Van Gordon2 describe some low temperature leadless glazes. Marquis3 describes some (one 01(1110.C) glazes for use on low temperature vitreous wares. These glazes contained large proportion of frit. Lehuhousen4 points out the advantage of adding BPo4 to glaze in small amount.

Recently S.Yoshida Y. Isutusum5 Japan has developed lead free frit for glazes. This study was carried out to develop new frits without using lead which is very harmful to human health. Lead free glaze for over glazeware prepared by using borosilicate glass containing La2o3. The raw materials used in this study were Chinaclay Silica, Znsio4, H3Po3, Baco3, Zno2, K2cod and La203. The flow chart for preparation of frit is shown in fig.No.1.

Materials

Mixing

Sieving 60 mesh screen

Melting (Firing temp.1300°C) soaking time 1 hr

Quenching (drop into water)

Drying (at 110°C)

Grinding (approx. 5 Micron)

Frit Powder

FIG.1.

TABLE NO. 1

FLOOR / WALL TILE MANUFACTURE
ITALY

COST STRUCTURE

RAW MATERIALS			
	SLIP	7.3%	
	GLAZE	16.7%	24.0%
- ENERGY			
	GAS	23.3%	
	ELECTRICITY	11.5%	34.8%
- WAGES		23.0%	
- MAINTENANCE		10.6%	
- PACKING		7.3%	
	TOTAL	100.0	

TABLE NO. 2

COMARATIVE PROPERTIES OF CORDIERITE PRODUCTS

Properties	unit	India* Type I	India ** Type II	UK	Europe
Max. Service Temp.	0C	1300	1250	1300	1300
Bulk density	g/cc	1.95-2.05	2.0-2.25	1.8	1.9
MOR					
At RT	kg/cm2	125-175	125-175	140	200
At 1250C	kg/cm2	100-125	60-90	140-170	N.A.
Apparent porosity	%	25-32	25-32	32	25
Thermal Shock Resistance		Excellent	Good	Excellent	-
Chemistry :					
A1203	%	45-50	45-50	47.0	34.0
Si02	%	40-45	40-45	44.0	55.0
Mgo	%	5-8	5-8	6.0	8.0

* Cumirite I
** Cumirite II

Crawling of glazes: Irregular contraction of glaze into this lumps and islands leaving bare unglazed patches is known as crawling. The following may be reasons for it.

i. Bad adherence of glaze to the ware surface.

ii. Over fine grinding.

iii. Too thick layer.

iv. Presence of constituents with large drying shrinkage such as plastic claysuncalcined zinc oxide organic bonders.

v. Reabsorption of moisture either before setting or in the preheating stage of firing.

vi. Moistware preheat rapidly.

FRITS :

when the glaze materials contain soluble salts like alkali carbonates or nitrates, borax etc. these salts are liable to to get dissolved in water and separate out from main mixture. In order to obviate this difficulty, these soluble salts are made insoluble by fussion them together with silica lime or leadoxide according to the composition of the glaze. This fused glass like mass is termed in pottery as frit, and the process of fusing is termed as fitting. The remaining insoluble portion of the glaze mixture is added to the frit and ground together with water.

There are several other advantages of fritting the glaze mixture and these can be stated as follows:

1. It minimises the difference in densities of the various constituents of the glaze and so reduces the chance of their setting down separately.

2. It drives out the Co2 and other gases and overcomes some of the heat work to be done by glost firing which is so essential in modern electric fired tunnel kiln.

3. It dismismies the solubility of the glaze in acids minimises lead poisoning certain ferms of lead salts such as white lead and lead sulphate are more soluble in human gactric juice than other lead compounds. In order to minimise the solubility in weakacid all lead glazes are required to be fritted before use.

4. It renders soluble materials insoluble.

If soluble materials are left alone, the biscuit ware will absorb some of them and on subsequent firing dense patches may form on these places where soluble salts get deposited most. Some in glaze colour are also attacked by presence of soluble salts in the glaze.

Fritted glazes are commonly used for whitewares and the tendency now is to use larger proportion of frit than formerly. In fact the all fritted glaze is now used for some type of wares.

TABLE -I

	Sio2	Zro2	A12o3	B203	Bas0	Zn0	Na20	K20	La203
Lead free frit	45.9	5.1	3.1	26.5	5.1	5.1	3.1	6.1	0.20

A new frit containing a certain amount of La203 in borosilicate glass was developed and having following properties.

1. The addition of La203 had no effect on the thermal expansion co-efficient.

2. Acid resistance and abrasive resistance were improved by a small addition of La203.

3. Colours of over glaze with La203 were almost similar to that of usual lead containing frit.

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