PAPER NO.

DEVELOPMENT OF METALLURGICAL REFRACTORIES WITH INDIAN RAW MATERIALS - PILOT PLANT STUDIES(*)

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Refractories play a vital role in the development of metallurgical industries. With rapid industrialisation in the country, demand for refractories is ever increasing and has been estimated at about one million tons per annum by the end of the 2nd Five Year Plan. The present production is of the order of 4,60,000 tons of refractories per annum. The gap between the present capacity and demand is largely being met by imports from other countries, thereby draining lot of valuable foreign exchange. Though there is no dearth of raw materials for refractory manufacture in our country, success of our refractory production programme depends on detailed and systematic investigation of various raw materials and their processing methods, effecting improvements in the quality of the products manufactured at present and development of compositions and processes for new products hereto not manufactured in the country. With this end in view, indigenous refractory raw materials have been scientifically and systematically investigated in this Laboratory. In all cases, before translating such laboratory efforts into commercial scale production, it is necessary that pilot plant studies should be carried out in order to obtain operating data which can be extrapolated with confidence in industrial practice. To meet this end a refractories pilot plant is being set up in this Laboratory. The projects which have reached a pilot plant stage of investigation are enumerated below:

(i) Dense mullite and hot face insulation refractories from bladed kyanite.

(ii) Zircon and sillimanite refractories from Travancore beach sands.

(iii) Magnesite refractories from Almorah magnesite.

(iv) Forsterite refractories from magnesium silicate rocks.

(v) Chemically bonded and metal clad mixed basic refractories.

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(vi) Stabilised dolomite refractories.

(vii) Chrome magnesite refractories from low grade chromites.

(viii) Carbon refractories from petroleum coke and low ash coals.

(ix) Dense carbon aggregates and soderberg paste from indigenous raw materials.

(x) Carbon bonded and clay bonded graphite crucibles.

(xi) Calcium aluminate cements.

(xii) Flux for union melt welding.

In Table I, are given physical properties of some of the products developed in the Laboratory.

In addition to the above projects, work is in progress in the Laboratory on the development of high alumina refractories from indigenous bauxites, superduty silica bricks from Jamda quartzites, silicon carbide refractories etc. It is proposed that, in the first instance, pilot plant development work will be carried out on projects which do not call for any special equipment other than that commonly needed for the production of conventional refractories, such as, studies on magnesite, forsterite, stabilised dolomite, chrome magnesite, chemical bonded, metal clad basic refractories, zircon, sillimanite, mullite and hot face insulation refractories. Pilot plant studies on carbon refractories, calcium aluminate cements and flux for union melt welding will be taken up at a later stage when equipment like hot mixer, reverberatory furnace etc. which are specially needed for these studies are installed.

Scope of the refractories pilot plant:

Although no special emphasis need be laid on the well known scope and functions of a pilot plant, such as scaling up of conditions based on the laboratory data to those of industrial production, study of variables in the unit operations of processes collection of economic data and product evaluation, it may not be out of place to illustrate the significance of some of these studies with reference to the actual refractory process developments. In the laboratory, the test specimens prepared are mostly restricted to small and simple shapes wherein the limitations of external dimensions and contour restrict the size of the largest particles that can be used to a certain maximum, whereas, in actual industrial size gradings somewhat larger grains could be used with advantage. Again, in the case of firing refractory specimens in laboratory experimental furnace where the heating chamber is small and the specimens are few in comparison, it is very easy to maintain uniform temperature throughout the chamber whereas in a large size industrial kiln, due to the quantity and size of the ware as also the volume of the furnace chamber, these conditions are difficult to attain. Pilot plant studies on the heat treatment of larger refractory shapes and sizes using semi-industrial size kilns are expected to throw light on the possible fluctuations of temperature in the kiln and will help in fluxing up a proper firing schedule.

Although the chief distinguishing feature of a pilot plant is that it produces materials not meant for sale on profit, there are certain special refractories which can be manufactured as a semi-commercial proposition.

In addition to these, pilot plant production of refractories will also help the metallurgist in studying their application in certain novel techniques which are tried from time to time. These studies include the production of iron by baby blast furnace as well as low shaft furnace, and steel by L-D and side blown convertor processes etc. Refractories required for these studies can be fabricated in our pilot plant and their service performance can be studied in close collaboration with the metallurgist in the Laboratory.

Last but not the least, a very important aspect of an integrated refractories pilot plant of the type being set up in this Laboratory would be the study of unit operations as applied in refractories industry based on fundamental concepts with a view to improvement on design of equipment and processing methods.

Description of the Proposed Pilot Plant:

The pilot plant has been planned as a general purpose unit for the production of different kinds of refractories with a rated capacity of about one ton of finished product per day of 8 hours work. The space allocated for Refractories in the pilot plant bay is 80 ft. x 30 ft. with an adjoining varandah 30 ft. x 14 ft. at one end. The lay out of the machinery and equipment has been planned in such a way that the material has a smooth unidirectional flow with minimum of backward and forward movements. The primary crushing of the hard and lumpy raw material will be done by a Jaw Crusher and the crushed material will be elevated to either of the two bins which are provided with bottom discharge, and are located on a platform. The crushed material from these bins will be transported and fed to any one of the four secondary crushers through portable hoppers fitted with vibratory feeders.

A single roll crusher, a disintegrator (hammer mill), a perforated-bottom pan mill and a solid granite bottom edge runner mill form the equipment for secondary crushing. These crushers will have a conveyor belt running under them, through which the crushed material will be transported and fed to a vertical bucket elevator which in turn feeds another horizontal conveyor at a height of about 20 ft. from the ground. This belt conveyor feeds the ground material to a double decker vibrating screen from which the two grain size fractions will be directed by canvas chutes into a battery of twelve bins of one ton capacity each. The over size from the screen will be either fed to a continuous ball mill or stored in one of the bins and subsequently charged into a batch type ball mill, for further grinding to fines.

Though a wind swept ball mill of about 3 cwt/hr. capacity would be ideal for this pilot plant, cost considerations have left no choice but to go in for a continuous type Hardinge mill for dry grinding or even to an ordinary batch type ball mill of appropriate capacity.

From the battery of bins the graded material will be drawn from the bottom into a hopper mounted on a portable platform/ scale and transported to the mixer. The muller mixer is provided with connections for running in measured quantities of organic binders such as sulphite lye, molasses and dextrin as well as water. Depending upon the method of formation to be adopted, the mix of appropriate moisture content will be conveyed either to the de-airing pug mill by a portable conveyor or to the ramming or hand moulding benches on wheel-barrows. The stiff mud extruded columns from the de-airing pug mill will be wire cut manually and repressed in a power-driven brick-cum-sagger press. Provision has been made for pressing saggers also in this press, since the same will be required for heat treatment of certain special items like carbon refractories etc..

Two other important methods of formation of bricks will be by a 500 tons hydraulic press and a pneumatic forge hammer both suitably adapted for making bricks and blocks. These two machines are already available in another building of this Laboratory.

The bricks formed by any one of the above methods would be loaded on drier cars running over 2 ft. gauge track. In the case of hand moulded shapes, preliminary air drying may be necessary. The loaded drier cars will pass through a temperature and humidity controlled tunnel drier. The drier will accommodate 5 cars at a time and the bricks will be dried on a predetermined schedule lasting about a week. If possible, provision will also be made to separate each of the cars by means of drop curtains and to have access to the same from one side so that they could be operated independently, if necessary. The tunnel drier will be provided with turn-tables at appropriate points. Blowers for recirculation of air in the drier and temperature and humidity controls will be provided.

The cars containing the dried bricks will be transported to either of the two rectangular down draft kilns with a capacity of 1000-1500 standard bricks. These kilns equipped with burners either for gas or oil firing are designed to attain a maximum temperature of 1600° to 1650°C. Suitable ceramic or metal recuperators will also be provided for preheating the combustion air, utilising the waste heat from the flue gases. Temperature indicators and recorders, flow meters for gas, oil and air as well as $CO-CO_2$ recorders for gas analysis will be provided so that full data could be collected for cost calculation etc. The final products that come out of the kiln will be sorted and dispatched either for service trials or for regular supply to meet the limited demands as discussed earlier.

It is also proposed to install a refractory casting section in the control room in the first floor for the production of refractory tubes, pots, muffles etc. The facilities already existing in the Laboratory for testing P.C.E., refractoriness-under-load etc. will be utilised for evaluation of the physical properties of the refractories produced in the pilot plant.

In addition to the equipment described above, it is contemplated to add certain special equipment like hot mixer, rotary calciner etc. at a future date, so that pilot plant studies can be carried out on projects like tar-bonded dolomite and carbon refractories.

Conclusions:

The refractories pilot plant being set up in the National Metallurgical Laboratory has many distinct advantages. It is hoped that valuable results will be obtained which will be of practical significance to industry.

/MRK/

TABLE I

Properties of some of the Refractories developed in the National Metallurgical Laboratory

	Dense mullite	Hot face insulation	Travancore beach sand		Magnesite (Almorah)	Forsterite	Chemically bonded magnesite.	Stabilised dolomite.	Chrome magnesite from low grade chrome ore.	Carbon	Graphite crucibles	
			Zircon	Sillimanite							Carbon bonded	Clay bonded.
% Apparent porosity	1) 0-7 2) 7-22 3) 20-26	58-60	22	25	26-27	20-24	Green 5 Fired 18	18-24	20-28	18-22	18	28
Bulk density	-	1.22	3.6	2.23	-	-	-	-	2.8-3.0	1.5	-	-
Modulus of rupture lbs/sq.inch	-	-	-	2300	-	-	-	-	-	-	1650	400
Compressive strength lbs/sq.inch	20,000-6,000	-	20,000	9000	-	-	Gr.10,000 Fi.13,000	-	4500-6600	4000-6000	1200	1000
Refractoriness under load ta°C te°C	1560 1600	1500 1630	1740 1900	1645 1655	1540 1545	- -	1520 1580	1450-1550 1650-1700	1510-1570 1570-1670	1800	Very high	1390
P.C.E. (Orton cone)	35	-	38	36-37	38	38	38	38	38	-	-	-
Thermal conductivity	-	1 BTU	-	-	-	-	-	-	-	-	-	-
Spalling resistance	-	-	30 cycles at 1000°C	30cycles	30 cycles at 1000°C	27-30 cycles at 1000°C	-	3-12 cycles	30 cycles	-	-	-
Slag resistance	Good	-	Excellent with molten aluminium.	-	Good with basic slag	-	-	Good with basic slag	Good with basic slag	-	21 charges with high nickel copper matte.	
Hydration resistance	-	-	-	-	-	-	-	Excellent	-	-	-	-