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MESSAGE FROM THE CHAIRMAN

Dear Colleagues,

As Indian steel industry plans to reach 300 million tonnes of crude steel capacity, an ambitious refractory industry is gearing up to provide the best of its services to the steel sector. The annual turnover of Indian refractory industry is around Rs 15000 crores and will witness a growth of at least 7-8% in the coming few years.

While we pull in our capital, ready the best of our technologies, buy the best of the raw materials, one thing missing in the link is the availability of quality manpower. Indian refractory industry is very heterogeneous staring from mighty multinationals, home grown big players to micro units for which the skill parameters of human capital assets are also different. This makes the task of skilling the human resource even more difficult.

Broadly speaking the skill gap at shop floor production level, application areas is gaining prominence in spite of India having a rich demographic dividend and unemployment being a practical problem. This brings before us the question of appropriate industry oriented skilling. It is a harsh fact that there is a question of employability of lakhs of engineers passing out of thousands of engineering colleges over the past few decades. A NASSCOM survey says every year almost 15 lakh engineers pass out but just over 2 lakhs land jobs. Low eligibility criteria for admission, poor quality of faculties, lack of infrastructure are responsible for mass scale production of unemployable freshers. On the other hand, students passing out of so-called Ivy League schools tend to avoid the core sector job opportunities, for IT, banking & finance etc although the career opportunities and work challenges offered by us are unique in their own right. We need to seriously think about image makeover of our industry, make the fresh passouts aware of the career opportunities offered by the core sector enterprises.

Ish Garg
Chairman


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ASSOCIATION ACTIVITIES

IRMA Board of Directors Meeting

IRMA Board of Directors meeting was held on 7th January 2023 on Zoom platform. The issues discussed were review of IREFCON22, future activities of the Association, election of new Deputy Chairman etc.

New Deputy Chairman of IRMA

As Dalmia Bharat Refractories Ltd has been taken over by RHI Magnesita India Ltd, Mr Sameer Nagpal, Deputy Chairman of the Association stepped down from the Board. The Board members expressed their deep appreciation for the activities initiated and supported by Mr Nagpal to strengthen the association body. The Board members by unanimous vote elected Mr Sunanda Sengupta (TRL Krosaki Refractories Ltd) as the new Deputy Chairman for the period 2022-24.

Meeting with Joint Secretary, Ministry of Steel

Indian Steel Association organized an online meeting with Mr Abhijit Narendra, Joint Secretary, Ministry of Steel and functionaries of Indian Refractory Makers Association. IRMA was led by Mr Ish Garg, Chairman along with Mr Sunanda Sengupta, Deputy Chairman and Mr Parmod Sagar. Mr Garg apprised Mr Narendra about the key findings of the white paper and sought his kind support to address the problems faced by the refractory makers particularly in the context of raw materials. Mr Narendran assured to look into the matter all the issues raised by IRMA.

IN THE NEWS

Domestic Steel Demand

ICRA has revised its outlook for domestic steel demand to 7-8 per cent for the next fiscal. Earlier, the ratings agency had estimated the demand to grow in the range of 6-7 per cent. India's crude steel production rose by 5.80 per cent to 124.45 million tonne (MT) in 2022, according to SteelMint. The country had produced 117.63 MT crude steel in 2021, the market research firm said.

JSPL

Jindal Steel & Power limited will be investing Rs 10,000 crore for setting up a 3 mn tonne per annum steel plant near Krishnapatnam in Andhra Pradesh as informed by its chairman Naveen Jindal. This will lead to creation of 10,000 jobs.

JSW Steel

Andhra Pradesh Chief Minister YS Jagan Mohan Reddy has laid the foundation stone for JSW Group's proposed steel plant at Sunnapurallapalle village in YSR Kadapa district. In the first phase, JSW steel will invest Rs 3,300 crore in the proposed plant and one million tonnes of steel per annum will be produced during the first year. The facility will be upgraded to two million tonnes per year in the second phase and will eventually reach three million tonnes capacity per annum. The total investment for all the three phases would be Rs 8800 crores.

India's Coal Production

India's coal output increased by 15.10 per cent to 784.41 million tonnes (MT) during April-February period of the ongoing fiscal. The country's coal output was at 681.5 MT in the year-ago period, as per provisional figures of the coal ministry. The country's coal production target has been fixed at 1,017 million tonnes for the next fiscal.

Dalmia Cement

Dalmia Cement (Bharat) Limited (DCBL), wholly owned subsidiary of Dalmia Bharat Limited has entered into a binding Framework Agreement for the acquisition of Clinker, Cement and Power Plants from Jaiprakash Associates Limited and its subsidiary / associate having total cement capacity of 9.4 MnT (along with Clinker capacity of 6.7MnT and Thermal Power plants of 280MW) at an Enterprise Value of Rs 5,666 Cr. These assets are situated in the states of Madhya Pradesh, Uttar Pradesh & Chhattisgarh.

The acquisition will enable Dalmia to expand its footprint into the Central Region and will represent a significant step towards realization of its vision to emerge as a Pan India Cement company with a capacity of 75 MnT by FY27 and 110-130 MnT by FY31.

Hindalco

Hindalco Specialty Alumina Chemicals team has solved a 130-year-old problem and turned Red Mud waste into an alternative raw material for the cement industry replacing finite mined minerals. Hindalco achieved 100 percent Red Mud utilisation at thee of its alumina refineries saving 4.5 mn tonnes of natural resources.

OVERSEAS NEWS

Nabaltec AG

Nabaltec AG had generated revenues of EUR 218.8 million in 2022, compared to EUR 187.0 million in the previous year (up 17.0%). According to preliminary figures, the operating profit (EBIT) was EUR 29.2 million – after EUR 24.6 million in 2021, which means another record year for the company.

Vesuvius PLC

Vesuvius PLC has reported an increase in annual payout to shareholders, as profit and revenue jumped during 2022, citing technological differentiation and its pricing strategy. The firm said pretax profit jumped 62% in 2022 to GBP207 million from GBP128 million in 2021. Revenue climbed 25% to GBP2.05 billion from GBP1.64 billion.

RHI Magnesita

RHI Magnesita has delivered robust performance in 2022. Revenue increased by 30% to €3.3 billion. The Company was able to increase its market share, with RHI Magnesita's shipped volumes in the steel segment broadly flat compared to a 7% decline in world steel production, excluding China. RHI Magnesita also reported strong progress in its target regions of China, Türkiye and India. The Company acquired SÖRMAS in Türkiye and the leading secondary raw material producer in Europe, MIRECO. Through two targeted acquisitions in India, Dalmia OCL and Hi-Tech, RHI Magnesita has strengthened its business in industrial markets and in flow control, whilst in China the Company has added flow control capacity through the agreed acquisition of Jinan New Emei.

Calderys

Following the completion of Harbison Walker International (HWI)'s acquisition by Platinum Equity by way of a merger agreement, the global investment firm confirmed Calderys and HWI will join forces to create a leading world-class refractories solutions provider. Michel Cornelissen, currently President and CEO of Calderys, is appointed Global CEO of the combined company, effective immediately.

Monocon International

Monocon International Refractories Ltd. (the wholly owned subsidiary of IFGL Refractories Ltd.) has completed the acquisition of 100% shareholding of Sheffield Refractories Ltd, ('SRL'). SRL is a manufacturer and installer of Monolithic Refractory products with a specific interest in Blast Furnace Cast House products, Shotcreting materials and an extensive range of other specialist Monolithic product for use in the Iron and Steel, Cement, Incineration and Waste to Energy Industries.

MEMBERSCAN

RHI Magnesita India

RHI Magnesita has firmed up capital expenditure to an estimated INR 36 billion ($439 million) over the next three years to ramp up capacities and modernize its Indian affiliates.

IFGL Refractories

IFGL Refractories Ltd has started commercial production at its new Precast products plant in Visakhapatnam manufacturing facility, effective Friday, 10th March, 2023. Installed capacity of new Precast Products plant is 8400 MT per annum and capital expenditure incurred for building the same is about Rs 1650 lacs.

Vesuvius India

Vesuvius Group will invest an estimated $61 million in its Indian arm to expand production and manufacturing bases across the country.

Imerys

The Vizag plant of Imerys currently has a capacity to produce 30 thousand tonnes of calcium aluminate binder for use in the Indian refractory and construction industries. Imerys plans to expand capacity to 50 thousand tonnes by 2030 to serve rising demand from the domestic steel and cement sectors, which continue to add capacity across the country. This makes the Vizag facility, the single largest site and investment in India for Imerys' refractory, and construction businesses.

ECONOMY AT A GLANCE

- India to witness GDP growth of 6.0 per cent to 6.8 per cent in 2023-24 and projects a baseline GDP growth of 6.5 per cent in real terms in FY24. India's GDP growth is expected to remain robust in FY24 at 7.0 percent (in real terms).This follows an 8.7 percent growth in the previous financial year.
- Economic Survey 2022-23 projects a baseline GDP growth of 1 percent in nominal terms and 6.5 percent in real terms in FY 24.
- Private consumption as a percent of GDP stood at 58.5 per cent in Q2 of FY23, the highest among the second quarters of all the years since FY15, supported by a rebound in contact-intensive services such as trade, hotel and transport.
- Capital investment outlay increased by 33% to Rs.10 lakh crore, effective capital expenditure at 4.5% of GDP and Capital investment outlay to be 3.3% of GDP in FY24.
- Effective capital expenditure of Centre at Rs.13.7 lakh in FY24.
- Fiscal deficit target below 4.5% of GDP by 2025-26, 6.4% retained in the Revised Estimate for FY23; reduced to 5.9% for FY24.
- FY23 net tax receipts revised estimate stands at Rs. 20.9 lakh crore, FY23 total expenditure revised estimate stands at Rs.41.9 lakh crore
- FY23 revised estimate of total receipts other than borrowing at Rs. 24.3 lakh crore.
- FY24 net tax receipts seen at Rs. 23.3 lakh crore.

BUSINESS SECTION:

ENERGY MAPPING OF CHIRKUNDA REFRACTORY CLUSTER: A SAMEEKSHA DOCUMENT

(Original work of TERI done under the project "INDIA: TERI-SDC Partnership: Scaling up Energy Efficient Technologies in Small Enterprises (EESE)

Chirkunda refractory cluster is the one of the most important industrial clusters in Jharkhand. The cluster is more than 100 years old. It is a notified area in Dhanbad district. The area is rich in mineral resources such as coal, lime stone, fire clay, china clay, granite, stone and sand. Some of the large industries in and around the cluster include, Maithan Power Limited (JV of Tata Power and Damodar Valley Corporation) and McNally Bharat Engineering. Apart from these, there are also a few large refractories units (Maithan ceramic limited, Associated ceramic limited, foundries - cupola based and induction furnace units and coke oven industries.

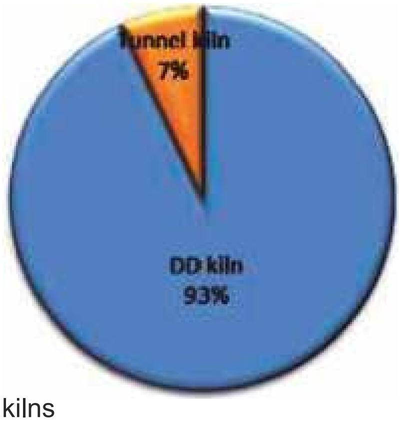
Chirkunda refractory industries in Jharkhand
Source: Google maps

The industries in the cluster under micro, small and artisan categories include engineering & fabrication, refractories, mineral, hand coke, etc. The refractory material produced are used within the country, with more than 80% of products are sold outside the state. The primary domestic market includes large steel manufacturing industries within 200 kilometre area like Tata Steel Ltd (Jamshedpur), TELCO (Jamshedpur), IISCO (Jamadoba), Bokaro Steel, SAIL (Durgapur), Alloy steel plant – Durgapur, etc. A small quantity is also exported to neighbouring countries like Bangladesh.

Product types and production capacities

There are about 129 refractory industries in the cluster of which about 120 units use down draft (DD) kilns and 9 units have tunnel kilns. The industries are located in about 10 kilometre radius. Some of the primary areas are Mera, Kumardhubi, Maithan, Mugma, Taldanga and Chirkunda etc.

The type of refractory products produced in the cluster include refractory blocks & bricks, graphite stopper head, insulation bricks, ladle, refractory mortar, ramming mass, roof bricks, silminite bricks, suspended roof bricks, monolithic, burner quarl, bottom pouring, silica brick, etc.



Distribution of kilns

The average production capacity of DD kilns is about 100 tonne per month (tpm) whereas of tunnel kiln is 600 tpm (equivalent to 20 tonne per day). The estimated average production of refractory products in the cluster is about 102,960 tonne per year (tpy). The average level of rejections from DD kilns is reported to be about 10%.

Technologies employed

(i) Downdraft kiln

Traditionally, Chirkunda refractory industries are using downdraft kilns for firing of refractory products. DD kilns are batch type systems, wherein loading and unloading of refractory products and firing is carried out manually. Coal is the fuel used in downdraft kilns. The traditionally designed DD kilns in the cluster have followings feature in common.

Design specifications of DD kiln, lining material and flue path layout are old and do not have proper design.

Downdraft kiln

- Coal is not properly sized before feeding into coal grate. It is also loaded at irregular intervals and varying quantities.
- Layout of existing coal grate and its capacity are unscientific thereby permitting flame/ flue to travel fast without proper heat transfer to refractory blocks
- Dampers are very provisional arrangement without proper manoeuvring lever in place resulting in high negative drafts
- Measurements of furnace temperature are not being done barring a few units which use pyrometer for measuring furnace temperatures
- There is no control of combustion air through coal grate which is always open. This provides no option for throttling to reduce airflow if felt necessary during firing cycle.
- Long flame carry over to chimney base was observed indicating high flue velocity and low residence time resulting in higher level of coal consumption.
- High surface temperature at loading / unloading area, which needs to be appropriately insulated with movable fixture for repeated use.

Most of the DD kiln units have two kilns with different size to cater variable production volume in a given season. The internal diameter of the kiln may vary within 18–30 feet (5.48-9.14 metre). However, flue path size and length depends on the individual site layout and chimney location, which is unscientific. Cycle time per batch production depends upon kiln size, quantity of refractory stacked, product mix in the stack and type of material under firing. The total cycle that includes stacking of green refractory, firing, cooling and unloading is about 20 days.

(ii) Tunnel kiln

Tunnel kilns are continuous type and can be operated using pet coke, oil and gas. There are about 9 number of tunnel kilns operating in the cluster. Of these, 3 tunnel kilns are smaller in capacities and operated continuously for short duration depending on market demands. The balance 6 tunnel kilns are owned by large players and are operated regularly at full production capacity.

Tunnel kiln

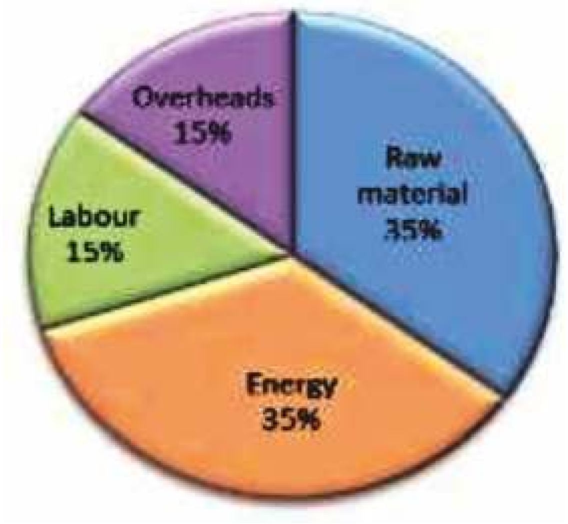
The tunnel kilns in the cluster use pet coke as the fuel. The refractory products loaded in trolleys, after removal of moisture in the dryer, are pushed inside the tunnel kilns Tunnel kilnusing an adjustable mechanical pusher mechanism. As the trolleys move inside the tunnel kiln, the products are gradually preheated close to about 700-800 °C before reaching firing zone. Pulverized pet coke is used as fuel in the cluster and is fed through an automatic fuel feeding system. The temperature of the firing zone is close to 1300°C wherein the products are soaked to about 1½-2 hours. The quantity of fuel is controlled through a feedback loop system with the temperature of firing zone. The products are gradually cooled down after the firing zone to about 50-60°C before they exit the kiln.

Kilns used in Chirkunda refractory cluster

Type of kiln	Number of kilns
Downdraft kiln	120
Tunnel kiln	9
Total	129

Energy consumption

Coal is the main fuel used in downdraft kilns and petcoke is commonly used in tunnel kilns for firing of refractory products. Electrically operated plant utilities such as press, crusher, muller, vibrating screen and belt conveyor are operated using power supply from local grid. Normally, power cut from grid does not interrupt firing cycle in DD kiln; tunnel kiln requires standby power source (generally DG set) to continue operation. The energy consumption in different kilns is also dependant on type of products and the firing temperature needed. The temperature requirements of different refractory products are in the range of 1280–1310°C.



Share of production cost

Fuels used in kilns

Type of kiln	Fuel used
Downdraft kiln	Coal
Tunnel kiln	Pet coke

The share of production cost for regular refractory products is same for energy as well as raw materials, which is about 35%. The raw material cost for better quality high end products may go up to 50% of total production cost.

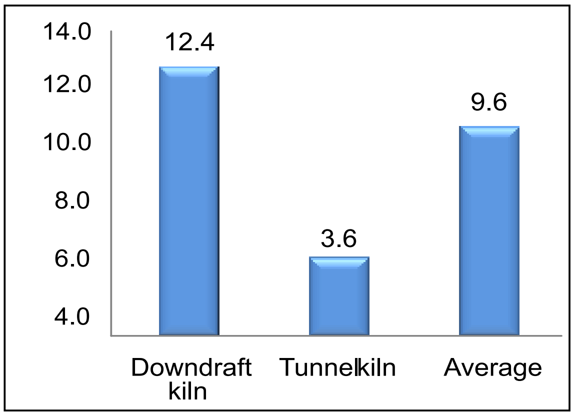
(i) Unit level consumption

Thermal energy (coal / petcoke) accounts for about 99% of share in total energy consumption in a refractory manufacturing industry. Product forming/ moulding is done through electrical presses but operated manually. However, the share of electrical energy consumption is negligible as compared to the energy consumption required for firing process. The total energy consumption of a ceramic / refractory unit varies between 249 toe per year (downdraft kiln) to 312 toe per year (tunnel kiln). The typical energy consumption by refractory industries in Chirkunda is shown in table.

Typical energy consumption of kilns

Type of unit	Thermal energy (tpy)	Diesel (kL)	Electricity (kWh/yr)	Total energy (toe/yr/unit)
Down draft kiln	378 tonne coal	0.28	29,400	249
Tunnel kiln	360 tonne petcoke	1.20	127,408	312

With the batch type process, the "specific energy consumption" (SEC) of downdraft kiln units is about 12.4 G J per tonne of refractory product whereas, the SEC of tunnel kilns of continuous type is about 3.6 GJ per tonne.



SEC variations at cluster level

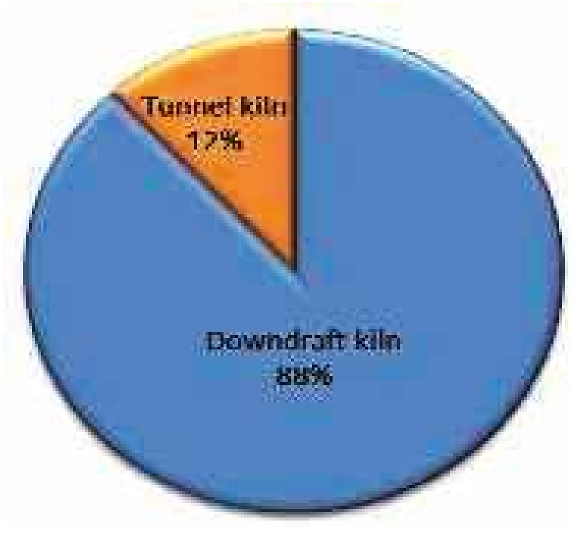
The weighted average SEC of refractory manufacturing at cluster level is about 9.6 GJ per tonne as shown in the figure. Higher SEC levels of DD kiln units may be attributed to a large mass of dead weight used in the kilns (support structure) along with the products. The typical energy consumption of downdraft kiln and tunnel kiln units and the SEC level of production are provided in table below.

Specific energy consumption of kilns

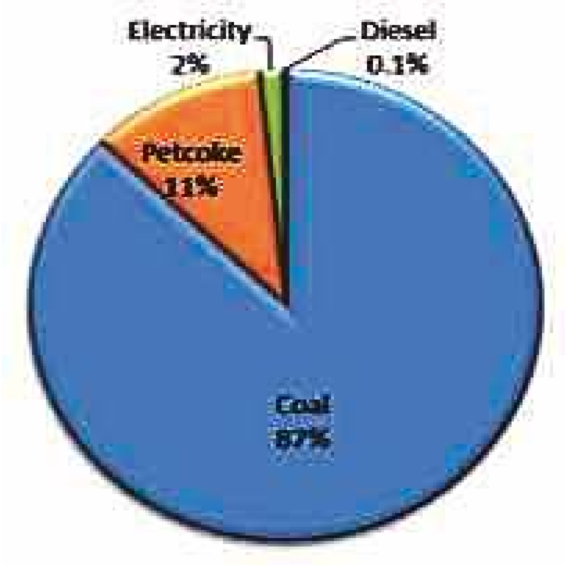
Kiln type	Specific energy kcal/kg	consumption GJ/t
Downdraft kiln	2958	12.4
Tunnel kiln	865	3.6
Overall	**2299**	**9.6**

(ii) Cluster level consumption

The total annual energy consumption at cluster level is estimated to be 23,674 toe. The share of energy consumption by coal is about 87% and of petcoke is 11% (figure). It may be noted that coal is consumed only by downdraft kilns and petcoke by tunnel kilns. The electricity consumption and diesel to meet power failure are negligible. The estimated GHG emissions from the cluster are about 100,430 tonne of CO_2. The break-up energy consumption and GHG emissions based on different energy sources is shown in table.



Energy consumption share at cluster level



Share of energy forms at cluster level

Energy consumption of Chirkunda refractory industry cluster (2016)

Energy type	Annual consumption	Equivalent energy (toe/yr)	GHG emissions (tCO_2/yr)	Annual energy bill (million INR)
Coal	31,752 tonne	20,639	83,349	286
Petcoke	3,240 tonne	2,657	13,014	49
Diesel	34.32 kilo litre	29	91	2
Electricity	4.06 Million kWh	349	3976	23
	Total	23,674	100,430	360

Energy saving opportunities and potential

Chirkunda refractory cluster offers significant scope for energy savings- from adopting best practices to energy efficient technologies. Some of the major energy saving opportunities in Chirkunda refractory cluster are discussed below.

(IDowndraft kilns use of insulating refractory in furnace lining

Traditionally, the linings of downdraft kilns are made mainly with low grade refractory bricks. Higher thickness of refractory inside walls and crown has led to considerable reduction in surface temperatures but have led to increased dead-mass resulting in higher heat losses during each firing cycle. It is suggested to modify existing lining with insulating refractories which would reduce heat losses through kiln surfaces. Further, ceramic fibre blankets can be added between layers of bricks in bottom layer, side wall and the crown that would help in reducing heat losses.

Sizing of coal and feeding practices

Coal is the primary energy source in downdraft kilns. It was observed that (1) large quantity of coal is fed every time without considering inside furnace temperatures and (2) coal lumps are fed and no proper sizing of coal is maintained. This leads to insufficient opening for combustion air supply resulting in thick black smoke from chimney exhaust. Thus improper fuel size and feeding practices have affected the thermal performance of DD kilns in the cluster. It is suggested to (1) use coal of about to 1 inch size before feeding and (2) maintain suitable fuel feeding frequency based on requirements of the kiln which would ensure improved and complete combustion of fuel and avoid formation of black smoke from chimney.

Installing temperature indicators for monitoring furnace temperature

The refractory industries in the cluster do not use temperature indicators for monitoring and controlling furnace temperatures. At present, furnace temperature and fuel firing is done through human judgement and skill level of firemen. This can lead to substantial variations in furnace temperatures vis-à-vis actual requirements for different products. Thus it can lead to (1) over-firing which can result in higher fuel consumption and damage to products, and (2) under-firing which can result in sub-standard product quality. It is suggested that all DD kilns must install on-line temperature probes at least in 3 locations at crown level of the kiln to monitor furnace temperature and control fuel feeding as per requirements.

Improved damper system for downdraft kilns

The downdraft kilns use locally precast circular ceramic material as damper system which is a crude design. These dampers do not have appropriate fixtures for adjusting their levels to control draft kiln draft. Existing practice of damper control is crude and non-scientific resulting in negative draft and loss of heat through high temperature flue gases. It is suggested to use ceramic board based damper system along with mechanical arrangement for movement of damper plate to increase or decrease the draft as per requirements. This would further improve ease of work for firemen.

Preheating of green refractory by flue gases

Traditionally built existing downdraft kilns in the cluster are unscientific and lacks proper layout as well as dimensions are inadequate. The chimney height is also more resulting very high negative draft in the furnace after initial firing cycle as dampers are not suitable to control the draft. Owing these facts, high temperature flue gases from downdraft kilns are vented out to chimney without any heat recovery system in place. Combustion air for firing coal in downdraft kilns are obtained with the help of natural draft, which is generated by connected chimney to the furnace. It would be easily possible to recover sensible heat from exhaust flue gases by integrating existing downdraft kilns in a manner to ensure flue gases are directed from source kiln to another kiln, which is loaded with green refractory and next in line for firing. Hence, the waste heat available in flue gases can be effectively utilised to preheat green refractory without installing any waste heat recovery system which can lead to substantial fuel saving.

Technology switch over for firing

Adoption of tunnel kilns

The SEC in tunnel kilns is 865 kcal/kg as against of 2958 kcal/kg in DD kilns. It would be possible to reduce energy consumption by about 70% by switching over to tunnel kilns with existing product volume. Other advantages with tunnel kilns include kiln automation, better monitoring and control of operating parameters, higher yield and enhanced production volumes. The estimated energy saving at cluster level is about 14,766 toe per year with tunnel kiln adoption.

Adoption of chamber kilns

Another potential option for DD kiln units is switch over to chamber kilns. In a chamber kiln, exiting flue gases are directed to flow to immediate following chamber after which the gases join central flue path connected with chimney.

The sensible heat in flue gases is recovered through preheating of refractories. Preheat temperatures of up to 1100°C are possible to achieve in chamber kilns and the temperature of exiting flue gases at chimney can be lowered to about 100°C. Thus the preheating of refractory product reduces the heat load requirements substantially leading to significant energy savings. The specific energy consumption in chamber kiln is 0.13 toe/tonne and estimated to save around 56% of energy if refractory products are fired using chamber kilns. At cluster level, about 11,698 toe per year can be by switching from downdraft kilns to chamber kilns.

(ii) Tunnel kilns use of low thermal mass cart

Green refractory products are loaded on to kiln cars to transfer inside tunnel kilns. Presently, kiln cars are made of metallic frame and refractory material resulting in higher dead weight and hence heat losses. Kiln cars can be fabricated using low thermal mass material which would help in reducing both dead weight of cars and heat losses. The weight reduction of the kiln carts in tunnel kilns provides significant scope to improve energy performance of tunnel kiln system. The following modifications can be incorporated to reduce the weight of the kiln cars:

- ⇒ Replacement of refractory bricks with the hollow ceramic coated pipes at the supporting pillars for holding racks
- ⇒ Use of ceramic fibre blankets at the base of the car instead of refractory brick base
- ⇒ Use of cordierite (hollow) blocks to hold the raw-wares instead of solid refractory mass

Reducing the dead weight by about 30%, heat losses from kilns can be reduced substantially. The envisaged fuel saving with dead weight reduction of trolleys in tunnel kilns is about 3% of total heat input equivalent to 64 to per year.

Enhanced insulation of tunnel kilns

The surface temperatures of firing zone of tunnel kiln are observed to be high leading higher heat losses and hence higher fuel consumption. It is suggested to introduce ceramic fibre blankets in tunnel kiln that would help in reducing heat losses from kiln surfaces.

Optimum furnace loading

The present level of loading of tunnel kilns was observed to be lower which may be attributed mainly to existing market conditions. It may be noted that various associated heat losses in tunnel kilns such as heat losses due to deadweight of trolley structure, surface heat losses, etc. would remain the same irrespective of loading of the kiln. Hence reduced loading would lead to higher specific energy consumption and hence higher production costs. It is suggested to plan optimum loading of tunnel kilns in order to minimise SEC levels.

Fuel switch over

The tunnel kilns in the cluster use petcoke as fuel. There is a significant potential to use other fuels such as processed rubber oil which may be explored by the refractory industries. The fuel switch over would help in reducing energy costs as well as close control of fuel firing.

Other energy saving measures

Other energy saving measures relevant for refractory industries in the cluster include the following:

- Power factor improvement with automatic power factor controller
- Installing energy efficient motors in different drives
- Use of clogged V-belts in place of flat belts
- Energy efficient lighting

TECHNICAL SECTION

A NOVEL CALCIUM MAGNESIUM ALUMINATE AGGREGATE FOR DRY GUNNING IN STEEL LADLES

GOUTAM BHATTACHARYA, CHRISTOPH WÖHRMEYER, FABIEN SIMONIN *IMERYS, KOLKATA, INDIA*

Abstract in Page 1:

A novel calcium magnesium aluminate aggregate (MagArmour) is used widely as additive in MgO-C bricks to improve service life of ladle linings by forming a coating on the lining. The same aggregate, when introduced partly replacing tabular alumina in a dry gunning composition was found to reduce weight of the lining while increasing the strength and thermal shock resistance of the composition. The article on page 3 discussed experiments and the results in detail which also supports a field test.

Introduction

A common practice to improve slag penetration and corrosion resistance of refractory monolithics is to use dense aggregates with very low porosity.However, the dense aggregates form dense lining leading to higher material consumption and higher heat loss. Also, the dense aggregate-containing compositions after sintering can form relatively brittle ceramics which are weak in resisting thermal shock [1]. Moreover, in general the slag attack starts with the matrix and once it is depleted, the dense aggregates which are relatively unaffected automatically fall off from the lining to the surrounding liquid [2]. Thus it may be possible to use a relatively porous aggregate without compromising the performance of the lining. Chen et al. [3] reported that MA spinel aggregate with higher porosity reduced the material consumption and thermal conductivity of the lining without compromising service life of a castable.

Calcium magnesium aluminate (CMA) is used widely in monolithics and precast shapes for steel ladles delivering two functions – hydraulic bonding due to calcium aluminate phases and corrosion and penetration resistance against ladle slag and metal thanks to the micro-fine magnesium aluminate (MA) spinel [4].In this study aggregates (coarser fractions)with a CMA composition (MagArmour) were used to partially replace the dense aggregate (tabular alumina) in a model gunning composition. The study covered the effects of the replacement in the gunning compositions focusing on

a) the weight change of the lining from the bulk density reduction

b) properties of the compositions – bulk density, apparent porosity, strength, thermal shock resistance as a function of Mag Armour addition.

c) field test results

Experimental Procedure

MagArmour (MagA) consists of ~70% magnesium aluminate spinel and the rest calcium aluminate phase.Bulk density (BD)of MagArmour is ~2.3g cm^{-3}, porosity ~30% and refractoriness 1755ºC. The microstructure (Fig. 1) of MagAreveals CA particles surrounded by CA_2 phase and MA spinel distributed throughout the microstructure with pores of different sizes. The reference dry gunning composition (Table 1) without MagArmour consisted of tabular alumina and sintered MA spinel aggregates together with 10 % Secar XR binder, which is suitable for gunning applications. It contained calcined and reactive alumina powder and no silica fume and additive. The reference composition (with 0% MagA) was compared with 3 other compositions, in which tabular alumina was replaced with 15%, 20% and 25% MagArmour with no other change. This replacement increased MgO and CaO and reduced Al_2O_3 (Fig. 2). MA spinel content also jumped with increase in MagArmour %.11% water was found to be suitable for placement of all compositions.The physical tests of the castables were conducted according to EN 1402. Thermal shock resistance was tested with 160 x 40 x 40 mm^3 samples after prefiring 3h at 1600ºC. The prefired samples were heated to 1000ºC and after holding for 30 min were cooled to the room temperature by blowing compressed air. 10 such cycles were performed. Modulus of Rupture (MOR) was tested on the samples before and after the thermal shock.X-ray diffraction (XRD) was carried out on fired (3h at 1600ºC) samples using a Bruker D8Advance X-raydiffractometer analysing Cu K radiation at 30 mAand 40 kV for the angles 2θ from 5°to 80°with intervals of 0.0197°.Crystal phases were quantified with Rietveld refinement.

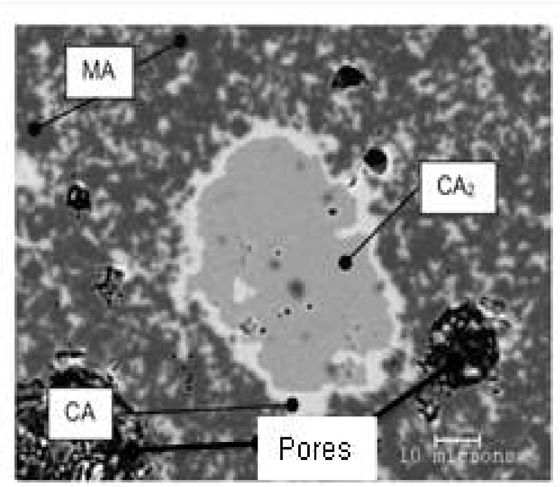


Fig. 1: Backscatter electron image of MagArmour

Table 1: Model compositions with progressive partial replacement of tabular alumina with MagArmour

Weight %		0% MagA	15% MagA	20% MagA	25% MagA
Tabular Alumina	0-3 mm	69	54	49	44
MagArmour	**0-3 mm**	**0**	**15**	**20**	**25**
Sintered spinel	0-1 mm	8	8	8	8
Alumina powder		13	13	13	13
Calcium aluminate	Secar XR	10	10	10	10
Total		100	100	100	100
Water addition		11	11	11	11

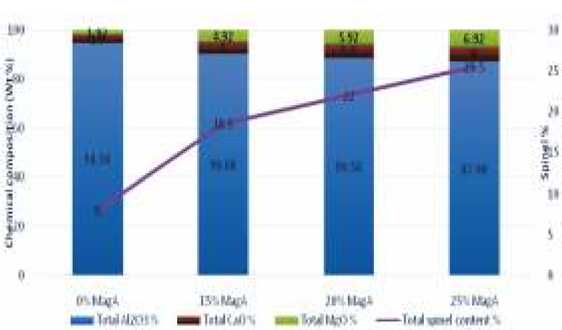


Fig. 2: Chemical composition and MA spinel content of the compositions

Results and discussion

Despite much higher porosity of MagArmour than tabular alumina, the substitution of MagArmour for tabular alumina did not result in higher water demand to achieve similar consistency in the gunning composition, which contained no deflocculant. Generally, for deflocculated castables it is common to have lower water demand for the castable which contains aggregates with lower porosity [5]. The bulk density of the MagArmour-containing compositions decreased compared to the MagArmour free composition. The reduction after 24h drying increased with increase in MagAmour content (Fig. 3) showing 5.2% reduction for the 25% MagArmour based composition. This reduction in the bulk density shows the amount of weight reduction of the lining for the same volume after drying. The theoretical reduction in bulk density for the 25% MagA composition from the 0% MagAis 7.8% considering the BD of tabular alumina as 3.55 g cm^{-3} and MagArmour 2.3 g cm^{-3}. Relatively lesser weigh reduction (5.2% vs 7.8%) may be attributed to the surface reaction of MagArmour with water forming calcium aluminate hydrates which dehydrates during preheating at higher temperatures. This reaction also explains an apparent mismatch between the BD and AP on replacement, i.e. AP remains largely similar despite a significant decrease in BD after 24h drying at 110ºC and firing 3h at 1100ºC and 1400ºC (Fig. 4). At 1600ºC AP decreased as MagArmour content increased possibly due to the presence of much larger amount of porosity in MagA aggregates leading to higher porosity reduction on sintering the compositions.

Fig. 3: Bulk density reduction of the MagArmour-containing compositions compared to MagArmour free composition after 24h at 110ºC

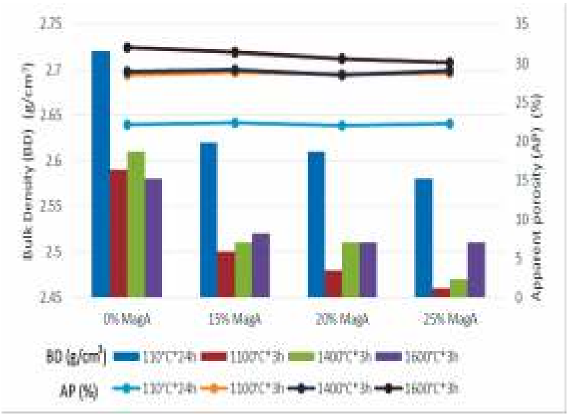


Fig. 4: Bulk density (BD) and apparent porosity (AP) of the compositions after heat treatment in different temperatures.

The strength (MOR) after 24h drying increased with increase in Mag Armour content despite decrease in bulk density (Fig. 5). This apparent anomalous relationship of strength with bulk density is also probably due to the hydration reaction of the calcium aluminate phases of the Mag Armour aggregate. CCS of the compositions increased with increase in Mag Armour % (Fig. 6). At 1100ºC, CCS for all compositions decreased compared to their respective dried strength (24h at 110ºC) due to dehydration of calcium aluminate hydrates leading to destruction of the hydraulic bond while sintering remained weak at this temperature. Such decrease is even more prominent for the high cement conventional castables. At higher temperatures, sintering led to progressive increase in strength. Permanent linear change (PLC) of the compositions (shrinkage) after 3h 1600ºC increased with increase in Mag Armour content (Fig. 7), which is consistent with the decrease in apparent porosity of the compositions. XRD after 3h at 1600ºC revealed that Mag Armour introduction did not increase CA_6 phase, whereas the content of CA_2 phase increased (Fig. 8). It indicates that there is shortage of reactive alumina and the available alumina (mostly tabular) is not sufficiently reactive to form CA_6. Formation of CA_6 leads to expansion and thus reduces the shrinkage of the composition on firing. The hypothesis was tested on the 20% MagA composition with a minor change - 3% additional reactive alumina was introduced replacing 2% MA spinel and 1% tabular alumina. The modified composition (20% MagA/V2) showed increase in CA_6 % and decrease in CA_2 % as expected (Fig. 8) and a significant reduction in PLC from -0.55% for 20% MagA to -0.1% (Fig. 7) [2]. MOR on thermal cycling (10 cycles) showed the highest loss in strength for the MagArmour free composition, whereas the 25% MagA showed the least (Fig. 9). Thus, substitution of MagArmour for tabular alumina for showed a clear advantage in terms of thermal shock resistance possibly due to the presence of calcium aluminate as binder as well as aggregate leading to close match in thermal properties. The positive laboratory results on thermal shock supports a previous field trial [6] in steel ladle in which MagArmour free gunning composition showed a service life of 18 heats, whereas the MagArmour-containing composition improved it to 31 heats (Fig. 10).

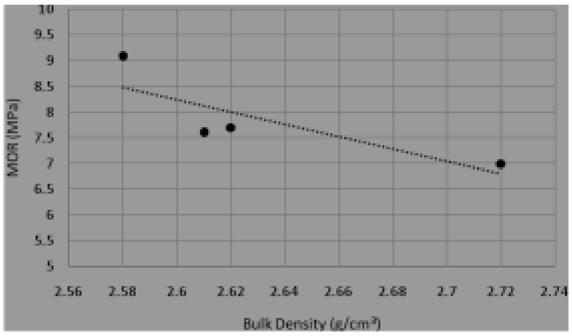


Fig. 5: MOR (MPa) of the compositions as a function of their bulk density

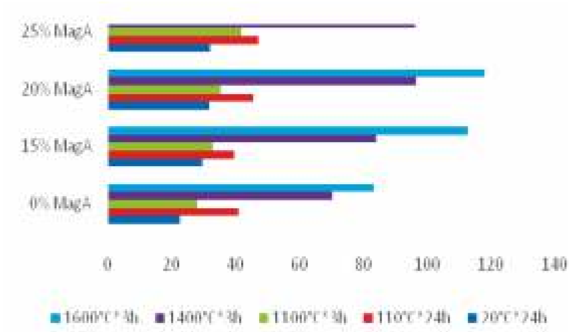


Fig. 6: CCS (MPa) of the compositions as a function of firing temperature

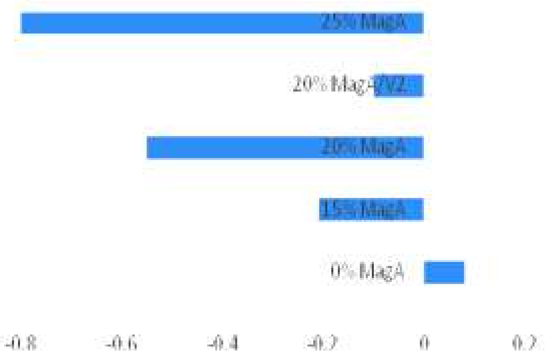


Fig. 7: Permanent Linear change (%) of the compositions after 3h at 1600ºC

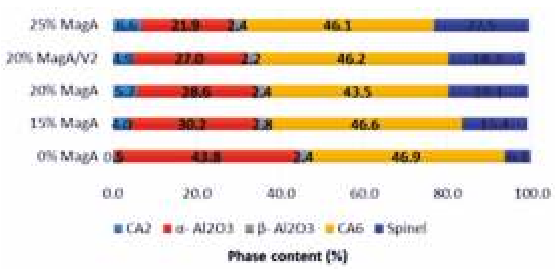


Fig. 8: Phase evaluationfrom quantitative XRD of the compositions after 3h at 1600ºC

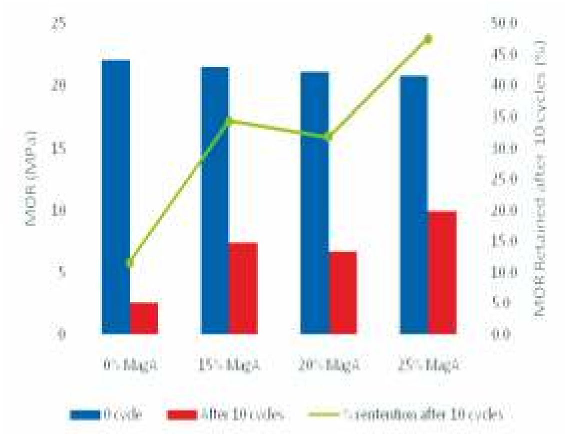


Fig. 9: MOR (MPa) before and after thermal cycling (10 cycles) from 1000ºC to room temperature and retained MOR

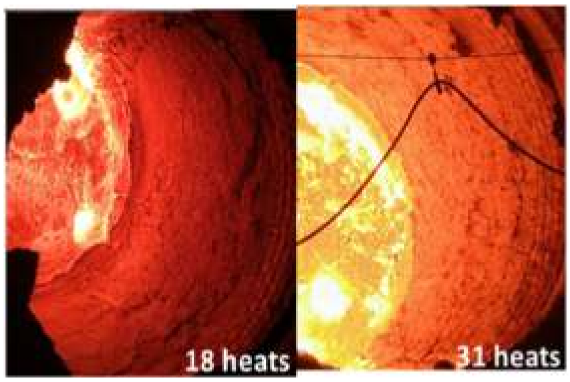


Fig. 10: Steel ladle lining at the end of their service life for an alumina-spinel gunning composition (left) and an alumina-MagA spinel composition (right). [6]

Conclusion

Substitution of the new multi phase aggregate (Mag Armour) for tabular alumina brought some unique properties in the gunning composition. The Mag Armour-containing compositions showed a drop in bulk density with an increase in strength, which is contrary to the common observations for the lower density and high porosity aggregates. Lower bulk density of the composition supports the sustain ability efforts thanks to the less material requirement for the lining. Higher strength of the Mag Armour based compositions after curing and drying is probably due to the additional hydration reaction of calcium aluminate phases at the surface of the Mag Armour aggregates and after firing at high temperatures probably thanks to the development of stronger ceramic bond due to the availability of larger reactive surface in Mag Armour compared to tabular alumina. Mag Armour based compositions also showed significantly better resistance to the thermal shock probably due to the continuity of the calcium aluminate phase in matrix as well as in aggregates. The positive field test results in steel ladle also further reinforced the lab findings.

REFERENCE

[1] Tang H, Li C, Gao J, Touzo B, Liu C, Yuan W: Optimization of Properties for Alumina-Spinel Refractory Castables by CMA

(CaO-MgO-Al2O3) Aggregates. Materials 2021, 14, 3050

[2] Wöhrmeyer C, Gao J, Szepizdyn M,Graddick S, Liu C:Designed Porous Aggregates – A Solution For More Sustainable Steel Ladle Refractories. UNITECR, Chicago, USA, 2022

[3] Chen R, He P, Wang N, Mou J, Gan F: Development of a low density castable forsteel ladle. http://www.baosteel.com

[4] Wöhrmeyer C. *et al*: Novel calcium magnesium aluminate bonded castables for steel and foundry ladles. UNITECR, Victoria, Canada, 2013

[5] Wöhrmeyer C, Parr C, Szepizdyn M, Zetterström C, Touzo B: Calciummagnesium aluminate aggregates for castables. ICR Aachen, 2017

[6] Wöhrmeyer C, Szepizdyn M,Mineau R.-M.,Gao J, Zhou Y:How to improve the bonding between used steel ladle castable substrate and dry-gunning repairmix. ICR Aachen, 2019

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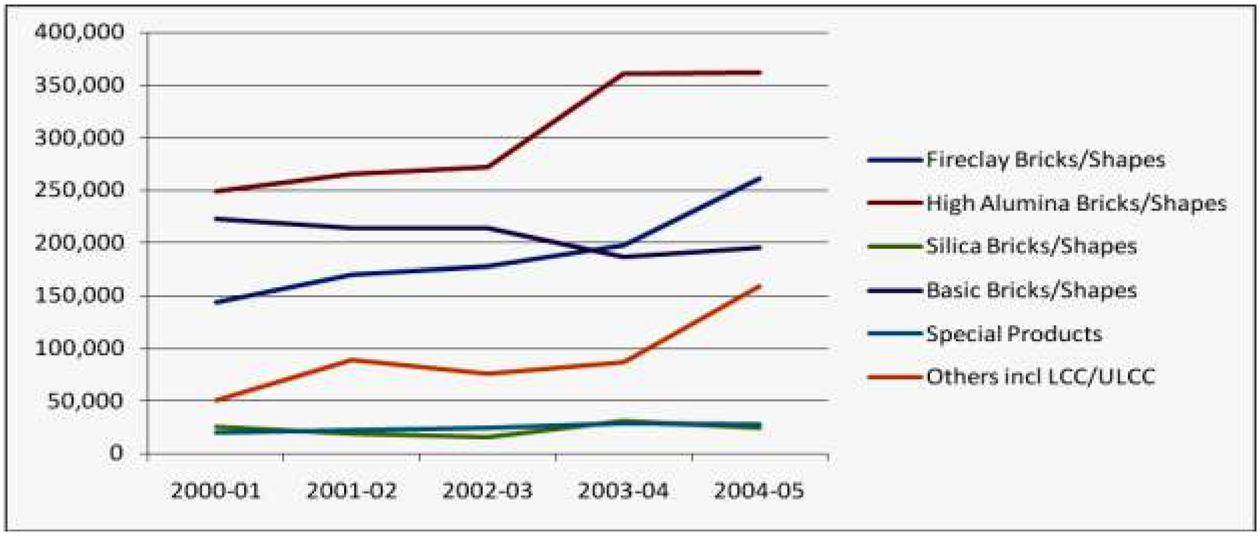
GLIMPSES FROM THE PAST

Todays as the turnover of Indian refractory industry is Rs 15000 crores, it is time to look back and trace the amazing growth projectile of the industry. Refractory industry in India has been traditionally dependent on steel industry whose share in refractories consumption has been around 75%. It needs to be noted that refractories production capacity in early 2000s was around 1.6 million tonnes, slightly less than today. This is because during that times specific consumption of refractories was much higher to the tune of 16-18 kg/ton of crude steel.

Refractory Production(mt)	Capacity	2000-01	2001-02	2002-03	2003-04	2004-05
Fireclay Bricks/Shapes	560,000	144,274	169,938	178,143	198,070	260,946
High Alumina Bricks/Shapes	410,000	249,243	265,267	271,945	360,671	361,836
Silica Bricks/Shapes	57,500	24,928	19,146	15,250	31,117	24,523
Basic Bricks/Shapes	336,000	222,687	214,082	214,346	186,816	195,912
Special Products	34,220	19,360	21,242	24,452	28,793	27,923
Others inclLCC/ULCC	253,800	50,908	89,262	76,126	86,467	158,893
Totals	1,651,520	711,401	778,938	780,263	891,935	1,030,033



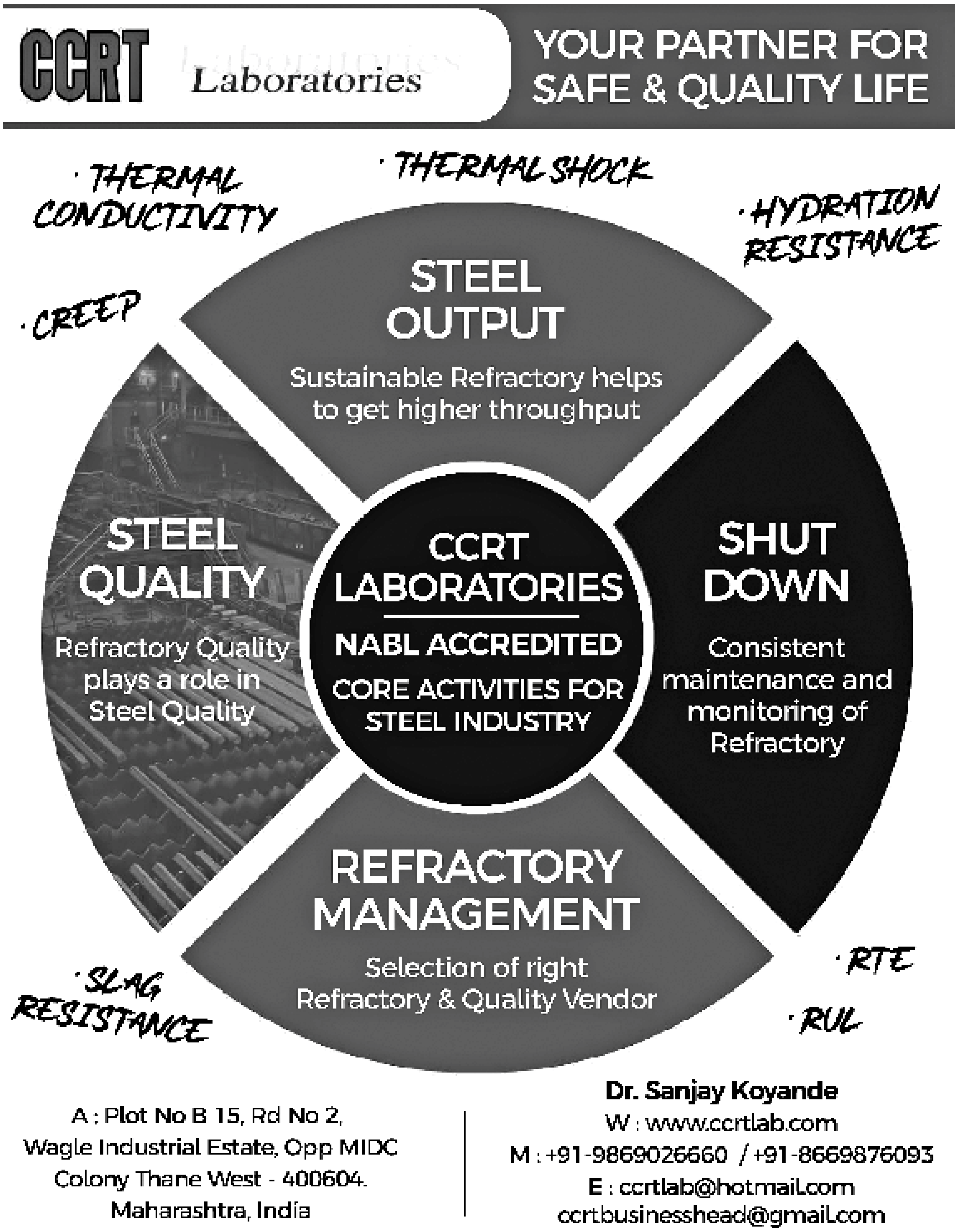
The graph shows that 2004-05 has been a good year for fireclay bricks and shapes, monolithics whereas for high alumina bricks sharp increase was observed in the year 2003-04. Comparatively the demand for silica bricks as well as flow control products remained flat in the discussed five years. There was steady decrease in basic bricks production in the country till 2003-04 while it slightly picked up in 2004-05. This can be attributed to penetration of Chinese basic products in the market. Demand for items like PCPF, ceramic fibres remained more or less flat.

As per JPC data, the capacity utilization of Indian steel plants in 2000-01 was 79% which moved to 91% in 2004-05.

STATISTICS

		2020-21		2021-22	
HSNCODE	IMPORT OF REFRACTORY RAW MATERIALS	m.t.	Rs. Lakhs	m.t.	Rs. Lakhs
26100010	CHROME ORE LUMPS CONTAINING 47% CR2O3ANDABOVE	0.2430	51.41	1.1610	277.15
26151000	ZIRCONIUM ORES AND CONCENTRATES / ZIRCON SAND	68.6752	69,933.78	94.8395	112,603.38
28256020	ZIRCONIUM DIOXIDES / FUSED ZIRCONIA	2.2858	13,766.49	3.4047	22,238.46

(Source: Ministry of Commerce, Government of India)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