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CONTENTS

MESSAGE FROM THE CHAIRMAN

Dear Colleagues,

In the recently concluded Board meeting of World Refractories Association, I have been appointed as the Chairman of World Refractories Association for a period of 30 months succeeding Ms Carol Jackson, Chairman and CEO of Harbison Walker International. Incidentally I'm the first person from Asian continent to be bestowed with the responsibility of representing global refractory industry.

I thank my colleagues in IRMA Board of Directors and the IRMA members who have reposed their faith on the me and proposed my name for this prestigious post.

It also shows that Indian refractory industry has finally arrived at global centre stage and its contribution is being recognized by all the leading international players.

With this post comes lots of responsibilities and lots of challenges. Globally the refractory industry faces a number of issues like scarcity of raw materials, make the industry economically and socially much more sustainable, attract the concern of the policy makers, get the best talents to work in this industry etc.

I solicit your cooperation and support as I firmly believe that time has come for the refractory industry to claim its due place in the niche of development. Ours is an industry of sunshine, of sustenance, of challenges laced with satisfaction of solving complex challenges of many a Goliaths of core sector industries. The chin music faced by us every day drives us to reach higher pinnacles of growth, of providing best operational excellency, higher lining life effecting in higher value creation for our customers. Our sonata is being written everyday in the bricks and mortars, the lining of which are life lines for our user industries.

Parmod Sagar
Chairman

ASSOCIATION ACTIVITIES

Raw Materials Pricing Index

IRMA is preparing a Raw Material Pricing Index on a monthly basis. The price information are being taken from established public platforms and the data are being shared with the members. This is being done to make them aware about the price fluctuations happening in the refractory raw material sector.

IREFCON 2022

IREFCON 2022 will be held at Hotel Westin, Kolkata from 16-18 November, 2022. The event will be organized both in physical as well as digital mode. Further detail follows.

IRMA Board of Directors Meeting

A meeting of IRMA Board of Directors was held on virtual platform on 27th March 2022 under the chairmanship of Mr P. Sagar. Issues discussed were market conditions, review of WRA activities and IRMA's support, IREFCON 2022, support to JRRDC Refractory cluster etc.

Support to JRRDC Laboratory

IRMA Board of Directors have sanctioned a sum of Rs 4 lakhs to buy equipment for the laboratory of Jharkhand Refractory Research & Development Centre.

IRMA Communications Committee

A Communications Committee has been formed by IRMA Board of Directors to be headed by Mr Ish Garg. The other members are Mr Kamal Sarda and Mr Abhijit Borah (of RHI Magnesita India Ltd). The main task of the Committee is to streamline the various activities of IRMA in social media.

IN THE NEWS

Indian Steel Production

India produced 120 million tonnes (MT) of crude steel during financial year ended March 31, 2022, Steel Minister Ram Chandra Prasad Singh has said.

At 120 MT, the output was about 18 per cent higher compared to the country's production in the preceding fiscal year.

According to official data, India produced around 102 MT steel in 2020-21.

JSW Steel

The country's largest steelmaker, JSW Steel, moved a step closer to realising its greenfield steel plant, with its wholly-owned subsidiary, JSW Utkal Steel (JUSL), receiving environmental clearance (EC) for setting up a 13.2 million tonnes (mt) steel plant in Odisha.

The company said the capital expenditure for the modern, green and environment-friendly ISP project is expected to be approximately Rs 65,000 crore, including associated facilities. The phase-wise work for the project will start once the land is handed over to the company by the government of Odisha.

The Company posted a combined crude steel production of 5.98 million tonne (MT) for the quarter ended March 31, 2022. At 5.98 MT, the production was 37 per cent higher compared to 4.36 MT steel the company had produced in the year-ago period.

Domestic Stainless-Steel Demand

Domestic stainless-steel demand is expected to reach 20 million tonnes (MT) by fiscal year 2047, according to a report.

In 2021-22, the country's demand for stainless steel was 3.7-3.9 MT, as per the 'Stainless Steel Vision Document 2047' released by Additional Secretary, Steel, Rasika Chaube at the Global Stainless-Steel Expo (GSSE) 2022. The report

said it expects, "stainless demand to register a compound annual growth rate (CAGR) of 6.6-7.5 per cent over fiscals 2022-2025 and reach 4.6-4.8 MT.

Tata Steel

Tata Steel has informed said that it has managed to achieve its highest ever production in India in FY22 at just over 19 million tons despite Covid-19 related disruptions. The FY22 production in India was 13% higher than the preceding year, as per a press statement. Tata Steel Europe registered a 6% growth in production to 10.1 tonnes, while production at Tata Steel Thailand declined by 8% to 1.29 tonnes.

RINL

Rashtriya Ispat Nigam Limited (RINL) has registered sales turnover of Rs 28,008 crore in the last financial year, 56 per cent higher than the previous year. RINL recorded a turnover of Rs 17,956 crore in 2020-21. In a press release, the steelmaker said it has achieved a record production of 5.773 million tonnes of hot metal, 5.272 million tons of crude steel and 5.138 million tonnes of saleable steel in FY22 despite facing Covid challenges and coking coal crisis.

NINL

Tata Steel Long Products has won the bid to acquire Neelachal Ispat Nigam Ltd (NINL) for around Rs 12,100 crore at a time when the steel sector is going through an upturn. NINL's capacity of 1.1 million tonnes can be increased up to 3.5 million tonnes, industry experts said. Also, its plant is close to Tata Steel's facilities in Kalinganagar.

OVERSEAS NEWS

Parmod Sagar is the New WRA Chairman

World Refractories Association (WRA) has appointed RHI Magnesita India MD and CEO as well as Chairman, IRMA Parmod Sagar as its president. "He (Sagar) has become the first from entire Asia to be appointed for the Presidentship of the global apex body of refractory makers," RHI Magnesita India, a WRA member, said in a statement. Mr Sagar succeeds Ms Carol Jackson, CEO and Chairman of Harbison Walker International, who was elected as WRA President in January 2020.

Ruitai Materials Technology

Ruitai Materials Technology released has the 2021 full-year performance report. In 2021, it realized operating income of 4.538 billion yuan, an increase of 7.63% year-on-year, and realized a total profit of 151.428 million yuan, an increase of 21.98% year-on-year. The steel segment achieved operating income of 2.728 billion yuan, a year-on-year increase of 8.18%. The glass sector achieved operating income of 473.509 million yuan, with a year-on-year increase of 18.92%. The cement sector achieved operating income of 1.055 billion yuan, with a year-on-year increase of 1.2%.

World Container Index

World Container Index decreased by 0.9% to $7,874.43 per 40ft container in early April 2022 but, remains 60.3% higher than a year ago. The average composite index of the WCI, assessed by Drewry for year-to-date, is $8,965 per 40ft container, which is $5,708 higher than the five-year average of $3,257 per 40ft container.

Worldsteel Short Range Steel Demand

As per Worldsteel, in the EU and the UK, steel demand is expected to fall 1.3% in 2022 to 161.5 million mt due the region's high dependence on Russian energy and refugee inflows, although demand was expected to grow 4% in 2023, the association said. In the

developed world, steel demand is expected to increase by a lower 1.1% in 2022 and 2.4% in 2023, after rising 16.5% in 2021. It said emerging economies outside of China would face challenges from the worsening external environment, the war, and US monetary tightening, leading to low growth of 0.5% in 2022 to 484.4 million mt and 4.5% in 2023, down from a growth of 10.7% in 2021.

Chinese steel demand slowed in 2021 due to government measures on real estate developers and worldsteel expected demand in 2022 to remain steady at 952 million mt, as Beijing looked to boost infrastructure investment and stabilize the real estate market. These stimuli are then due to support steel demand growth of 1% in 2023 to 961.6 million mt.

China Refractory Raw Materials Index

According to Refwin, the China Refractory Raw Materials Price Index in March 2022 was 211.21, a month-on-month decrease of 0.62% and a year-on-year increase of 17.9%.

MEMBERSCAN

RHI Magnesita India

RHI Magnesita plans to double the capacity of its plants to 280,000 tonnes by FY23 for an investment of Rs 450 crores. The company has nearly 20% share in the Indian refractories segment.

TRL Krosaki Refractories

TRL Krosaki has commissioned a state-of-the-art 100 MT per month alumina graphite plant at Belpahar. The facility has been set up at an investment of Rs 65 crores with the technology of Krosaki Harima Corporation. This plant is expected to give TRL Krosaki a cutting edge in manufacturing of continuous casting products.

IFGL Refractories

The Company has recently procured two plots of land admeasuring more or less 9 400 Sq. Mtrs on long term 15 years lease situated in vicinity of existing facility from KASEZ Authority.

Dalmia Bharat Refractories

Dalmia-OCL, which recently announced the merger of its entire refractory business into a single entity called Dalmia Bharat Refractories Ltd (DBRL), is expecting 20-25% growth in business in FY23 backed by a steady demand from Indian steel and cement sectors and also from international customers looking for alternatives to China in terms of supply chain.

According to Sameer Nagpal, MD and CEO, DBRL, the company has grown around 20-25% over the pre-pandemic levels and is likely to close the current fiscal with a turnover of around 1,200 crore. It is hopeful of doubling the turnover by 2025.

Eirich India

The ground-breaking ceremony for the construction of the new plant site of the subsidiary of Eirich India took place on 11th April 2022 at the Chakan industrial area in Pune. It is planned to start production of Eirich machinery and equipment as early as Q1 2023.

BUDGET 2022-23 AT A GLANCE

- GDP growth rate projected in the range of 8-8.5% for the next fiscal 2022-23 (FY23) Growth projections based on oil price projection of $70-75 per barrel next fiscal, against current price of $90.
- The Union Budget for FY 2022-23 this year aims to strengthen the infrastructure with its focus on four priorities of:
  - PM GatiShakti
  - Inclusive Development
  - Productivity Enhancement & Investment, Sunrise opportunities, Energy Transition, and Climate Action
  - Financing of investments
- Enhanced outlay for 'Scheme for Financial Assistance to States for Capital Investment' from Rs.10,000 crore in Budget Estimates to Rs.15,000 crore in Revised Estimates for current year. Allocation of Rs.1 lakh crore in 2022-23 to assist the states in catalysing overall investments in the economy: fifty-year interest free loans, over and above normal borrowings
- In 2022-23, States will be allowed a fiscal deficit of 4% of GSDP, of which 0.5% will be tied to power sector reforms.
- 130 lakh MSMEs provided additional credit under Emergency Credit Linked Guarantee Scheme (ECLGS). ECLGS to be extended up to March 2023. Guarantee cover under ECLGS to be expanded by Rs.50000 Crore to total cover of Rs.5 Lakh Crore. Rs.2 lakh Crore additional credit for Micro and Small Enterprises to be facilitated under the Credit Guarantee Trust for Micro and Small Enterprises (CGTMSE). Raising and Accelerating MSME performance (RAMP) programme with outlay of Rs.6000 Crore to be rolled out.
- Outlay for capital expenditure stepped up sharply by 35.4% to Rs.7.50 lakh crore in 2022-23 from Rs.5.54 lakh crore in the current year. Outlay in 2022-23 to be 2.9% of GDP. 'Effective Capital Expenditure' of Central Government estimated at Rs.10.68 lakh crore in 2022-23, which is about 4.1% of GDP.
- Additional allocation of Rs.19,500 crore for Production Linked Incentive for manufacture of high efficiency solar modules to meet the goal of 280 GW of installed solar power by 2030. Five to seven per cent biomass pellets to be co-fired in thermal power plants:
  - CO_2 savings of 38 MMT annually
  - Extra income to farmers and job opportunities to locals
  - Help avoid stubble burning in agriculture fields
  - Four pilot projects to be set up for coal gasification and conversion of coal into chemicals for the industry
- Government contribution to be provided for R&D in Sunrise Opportunities like Artificial Intelligence, Geospatial Systems and Drones, Semiconductor and its eco-system, Space Economy, Genomics and Pharmaceuticals, Green Energy, and Clean Mobility Systems.
- 100 per cent of 1.5 lakh post offices to come on the core banking system. Scheduled Commercial Banks to set up 75 Digital Banking Units (DBUs) in 75 districts.

BUSINESS SECTION

AN OVERVIEW OF MINES & MINERALS (DEVELOPMENT & REGULATION) AMENDMENT ACT, 2021

By a Special Correspondent

Introduction

The Mines and Minerals (Development and Regulation) Amendment Act 2021 was introduced in the Lok Sabha on 15th March 2021 and subsequently passed by the Rajya Sabha on 22nd March 2021. This Amendment modifies significant sections of The Mines and Minerals (Development and Regulation) Act, 1957 that regulates the mining sector in India. The reforms made are in the provisions related to statutory requirements, removal of end-use restrictions for captive mines and the division between captive and non-captive mines, transfer by auction of mineral-concessions, National Mineral Exploration Trust (NMET), National Mineral Index(NMI), the inclusion of private sector, Section 4 (1), _Section 8 (B)of the Mines and Minerals (Development and Regulation) Act, 1957 and so on.

This Bill has several objectives. Primarily, it is attempting to harness the potential of the mineral sector by increasing employment rates and increasing investment levels within the mining and coal industry. It is looking to increase revenues generated by the mining sector. In addition, a methodology is developed to enhance transparency in the overall auction process, and in order to raise the levels of exploration and auction for mineral resources. Finally, it wishes to resolve ramifications that have been occurring in the past. With the backdrop outlined, let us get into a detailed study of the recent amendments made herein.

Key regulations of the Act

The 1957 Act deals with mainly three concerns of the mining leases, purpose for granting these leases and its auction procedures along with ensuring the welfare of the inhabitants of a mining site. As per the Act, there are two categories of operational mines, namely; captive mines and open mines. The former is almost always associated with some specific purpose. For instance, an iron ore mine provides all of its ore extractions to a predetermined steel plant and nowhere else.

Another example could be a limestone mine that provides raw materials only to a predesignated cement plant so that the purpose of the mine, in that case, is to facilitate only specific industries/sectors for a fixed period. Alternatively, the latter is also known as non-captive mines. The minerals extracted from these mines are sold in open markets or used for their consumption. The reform made within this background allows all mines to sell 50% of their minerals in the open market with one caveat. The company has to pay an additional amount of money to the state government for selling its products in the open market. Thereby, the reforms get rid of the end-use restrictions on these mines.

During the auction of a mine, the lessee obtained a fresh set of statutory permissions. The 2021 Bill sets aside this step as redundant. So, now the previously obtained set of statutory clarifications move to the new persons selected through the auction process for regulating operations at the mining site. Further, if the state government does not conduct an auction that it is supposed to hold for an extended time, then the Central government has the power to step in and make the auction possible.

A glimpse at the new amendments

- Removal of restriction on end-use of minerals: The Act empowers the central government to reserve any mine (other than coal, lignite, and atomic minerals) to be leased through an auction for a particular end-use (such as iron ore mine for a steel plant). Such mines are known as captive mines. The Bill provides that no mine will be reserved for particular end-

use.

- Sale of minerals by captive mines: The Bill provides that captive mines (other than atomic minerals) may sell up to 50% of their annual mineral production in the open market after meeting their own needs. The central government may increase this threshold through a notification. The lessee will have to pay additional charges for mineral sold in the open market.
- Auction by the central government in certain cases: Under the Act, states conduct the auction of mineral concessions (other than coal, lignite, and atomic minerals). Mineral concessions include mining lease and prospecting license-cum-mining lease. The Bill empowers the central government to specify a time period for completion of the auction process in consultation with the state government. If the state government is unable to complete the auction process within this period, the auctions may be conducted by the central government.
- Transfer of statutory clearances: Upon expiry of a mining lease (other than coal, lignite, and atomic minerals), mines are leased to new persons through auction. The statutory clearances issued to the previous lessee are transferred to the new lessee for a period of two years. The new lessee is required to obtain fresh clearances within these two years. The Bill replaces this provision and instead provides that transferred statutory clearances will be valid throughout the lease period of the new lessee.
- Allocation of mines with expired leases: The Bill adds that mines (other than coal, lignite, and atomic minerals), whose lease has expired, may be allocated to a government company in certain cases. This will be applicable if the auction process for granting a new lease has not been completed, or the new lease has been terminated within a year of the auction. The state government may grant a lease for such a mine to a government company for a period of up to 10 years or until the selection of a new lessee, whichever is earlier.
- Rights of certain existing concession holders: In 2015, the Act was amended to provide that mines will be leased through an auction process. Existing concession holders and applicants have been provided with certain rights including: (i) right to obtain prospecting licence or mining lease to a holder of reconnaissance permit or prospecting licence (issued before commencement of the 2015 Amendment Act), and (ii) right for grant of mining lease where the central government had given its approval or letter of intent was issued by the state government before the commencement of the 2015 Amendment Act. The Bill provides that the right to obtain a prospecting license or a mining lease will lapse on the date of commencement of the 2021 Amendment Act. Such persons will be reimbursed for any expenditure incurred towards reconnaissance or prospecting operations.
- Extension of leases to government companies: The Act provides that the period of mining leases granted to government companies will be prescribed by the central government. The Bill provides that the period of mining leases of government companies (other than leases granted through auction) may be extended on payment of additional amount prescribed in the Bill.

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TECHNICAL SECTION

TECHNOLOGICAL PROGRESS IN DOLOMITE REFRACTORY: A SHORT REVIEW

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Abstract

Dolomite is a double carbonate of magnesium and calcium [MgCa $(CO_3)_2$]. It is being used as a refractory lining material mainly for steel and cement industries. This article deals with the technological progress in Dolomite refractory with the changes in steelmaking processes. Dolomite was originally used in the stabilised or semi stabilised form as fettling materials for the hearth of Bessemer converters. Since the introduction of Basic Oxygen process of steelmaking in LD converters tar bonded dolomite and mag-dolo brick technology was adopted. Later on use of tar bonded products were discontinued for LD process and magnesia carbon refractory, which has superior corrosion and thermal shock properties were introduced as working lining materials. At present fired dolomite bricks are the main lining materials for stainless steel making in AOD converters, due to its excellent thermodynamic stability in reducing or vacuum atmosphere. The paper is a short review on the chronological technology development on dolomite refractory with the changes in steelmaking processes.

Introduction

Technological advancement in refractories is closely related with the historical transitions in steelmaking technology with ever increasing stringent operating conditions. Refractory in the MgO-CaO system is one of the prime refractory used in steelmaking due to its basic nature and excellent high temperature properties. The system comprises Magnesia, Magnesia enriched dolomite, dolomite and Lime refractory. For the last several decades Magnesia is being used for lining in Basic oxygen process of steel making (LD Converter). Dolomite (MgO-CaO) and Magnesia enriched dolomite are currently important refractories for stainless steel making in AOD converters. Dolomite refractory has also a major application in cement kilns. However, the present paper will focus on the development of Dolomite Refractory related to the historical modification in steelmaking process.

Dolomite is a basic refractory material with the ideal composition [MgCa $(CO_3)_2$]. Doloma (MgO.CaO) produced from dolomite consists of a phase mixture of lime and periclase. The binary diagram in the system MgO-CaO have extremely high eutectic temperature of 2370°C [1]. It also possess exceptional thermodynamic stability [2] due to presence of high amount of CaO phase. It has relatively low vapour pressure at elevated temperature [3], which is the prime requirement of a refractory for secondary steelmaking processes that uses vacuum technology. In spite of all these fundamental advantages, sintered dolomite tends to hydrate in contact with atmospheric moisture due to the presence of predominant CaO phase. It is susceptible to hydration and degradation by some ferruginous metallurgical slags [4]. Varying amounts of impurities including SiO_2, Al_2O_3 and Fe_2O_3 are present in dolomite [5-6]. The amounts and types of these impurities may have a large effect on the extent of densification. To minimize this problem, at earlier times stabilized doloma was used, which was produced by reaction of dolomite with silica, serpentine or iron oxide materials [1]. The main phases formed due to these reactions are periclase (MgO), tri-calcium silicate ($3CaO.SiO_2$), which controls hydration of refractory.

$$6(CaCO_3.MgCO_3) + 3(MgO.2SiO_2.2H_2O) = 2(3CaO.SiO_2) + 9MgO + 2H_2O + 12CO_2$$

These bricks were used in sub-hearth of furnaces, furnace side walls and ladles.

Dolomite refractory was originally used as fettling material for the hearth of Bessemer converters [7].

In India, since the introduction of LD converters in 1960's, sintered dolomite was used in the tar bonded dolomite refractory. The introduction of basic oxygen process of steelmaking (LD Convertor) demanded to develop this refractory from highly dense and corrosion resistant sintered dolomite. This was essential not only to resist hydration but also to hinder the slag infiltration and corrosion against the refractory [8-9]. At that period tar bonded dolomite bricks was mainly produced in the steel industry. The densification of purer varieties of dolomite needs high sintering temperature, due to its high refractoriness. High density sintered dolomite (3.20-3.30g/cc) can be produced either through single step process at 1700 - 1850°C in shaft or rotary kiln or by two stage calcination process at 1000°C and 1600 °C respectively. The sintered dolomite grains are required to produce dolomite refractory with low rate of wear against basic slag. However, after 1980's it has been established that in the environment of high basic slag ($CaO:SiO_2$::3:1) magnesite is superior to dolomite. Magnesia Carbon refractory, after its development in mid 1980's substituted tar / Pitch bonded dolomite for primary steelmaking. However, in stainless steel making particularly in AOD process dolomite gained its importance. Its stability is better than magnesite when the atmospheric condition is reducing or and under vacuum. In stainless steel manufacturing the slag basicity ranges between 1.5 to 2 and in this condition CaO perfoms well.

Sintering of Dolomite:

Dolomite grain are generally sintered/ dead burned by single stage process carried out at high temperature above 1700°C in shaft or rotary kiln to produce high density and homogeneous microstructure of CaO and MgO crystals. The densification and hydration resistance can be further improved by using two-stage sintering. In this process the dolomite initially decomposed to produce highly reactive powders, hydrated, followed by pelletisation and 2nd sintering around 1600°C to develop grain density around 3.25 gm/cc. The properties of sintered dolomite produced from these processes are illustrated in Table I.

Table I: Properties of sintered dolomite [10]

Properties	Two stage sintering at 1000° and 1600°C		Single stage sintering 1700° C
	Impure	Pure	
Bulk Density, g/cc	3.20	3.30	2.90-2.95
App. Porosity, %	2.5	1.5	8-12
Hydration resistance (at 71°C, 85% RH, 24 hrs), Wt loss%	14.9	7.5	80

It is known that for single stage sintering the surface area of the original carbonate decomposes after 1000°C is 1 m^2/gm. Whereas for two stage sintering the oxide derived from hydroxides at 600°C ranges between 25-30 m^2/gm. The early borned oxides from hydroxides undergoes plastic flow and shows significant sinterability at lower temperature. Moreover, the water vapour evolves from hydroxides enhances the sintering by lowering the dihedral angle between grains and pores [11]. During the sintering of dolomite, it was observed that the CaO grains adhered to each other grow faster than MgO grains and as a result bigger CaO grains are formed [19]. It was suggested that the reason of this is the bond energy of CaO

molecules are lower than MgO molecules and they can move in the crystal structure [12].

Additives play an important role in the sintering of dolomite. It is reported that Fe_2O_3 reacts with CaO of dolomite to form dicalcium ferrite, which favours liquid phase sintering. On the other hand Fe-ions forms solid solution with MgO and creates cation vacancy, which is also responsible to enhance solid state sintering in dolomite.

Tar / Pitch bonded Dolomite and Magnesia-enriched Dolomite Refractory for LD Converter

Since the introduction of LD convertor for primary steelmaking it was lined with tar / pitch bonded dolomite / magnesite refractories [13]. In India these refractories were produced in the captive unit of integrated steel plants from 1960's to mid 1980's. This refractory is manufactured by mixing size graded sintered dolomite grains with 5-10% tar / pitch followed by pressing and finally tempering between 200 – 300°C. [14]. Thereafter, with the invention of high performance MgO-C refractory, the converters were lined only with this refractory. It was established that in the furnace environment comprising highly basic slag, MgO-C refractory is the best option to increase the lining life.

Typical properties of Tar/Pitch bonded dolomite and mag-dolo bricks is given in Table II . It can be seen that after tempering the compressive strength and hydration resistance significantly improved. The use of sintered MgO-grains to tar bonded dolomite refractory is well established [15]. The coclinker are produced by mixing finely divided MgO and doloma and dead burning to develop high density and uniform microstructure of MgO and CaO grains. The properties of mag-dolo is superior than doloma due to presence of hydration resistant and slag corrosion resistant sintered / fused MgO in this environment.

Table II Properties of Pitch bonded dolomite and Mag-dolo blocks after tempering [15]

Type of Bricks	% MgO	Bulk Density, gm / cc	Apparent Porosity, %	Hydration Resistance at 60°C and 50% relative humidity (% weight gain)
Dolomite	42	3.30	1.7	7.5
Magnesia enriched Dolomite 'A'	55	3.31	1.4	2.3
Magnesia enriched Dolomite 'B'	76	3.34	2.5	0.8

Dolomite Refractory for stainless steel making (AOD Convertor)

Stainless steel is manufactured in AOD convertors, which operates in the temperature range of 1700 to 1740°C. The refractory wear is caused by erosion of molten metal, gas turbulances of vessel and slag of basicity ($CaO:SiO_2$) of 1.5 to 2.0. To withstand this condition the refractory should possess high refractoriness under load (RUL), volume stability and thermal shock resistance [16]. Initially direct bonded magnesite chrome (DBMC) bricks were used in the working lining of AOD converters. However, later on it was observed that DBMC lining suffered and the oxide gets reduced (Cr_2O_3. Fe_2O_3 Cr.Fe) due to the reducing atmosphere prevailing in these vessels. Thereafter, the lining was shifted to burnt dolomite and mag-dolo refractory, since it have several improved properties including environmental friendliness. This refractory is produced from sintered dolomite added with or without magnesia grains mixed with non-aqueous binders (to avoid grain hydration), pressed and fired at high

temperature. It has been reported that monoclinic zirconia additives in Dolomite brick improves properties like crack arresting by formation of $CaZrO_3$ phase. The thermal expansion mismatch between $CaZrO_3$ and MgO grains may develop microcracks which arrest the crack propagation. Sintered dolomite, consisting basic compounds of CaO and MgO possess lower amount of impurities SiO_2, Al_2O_3 and Fe_2O_3. Being a thermodynamically stable material, it is not affected in reducing conditions prevalent during stainless steel manufacturing. The partition coefficient of oxygen between dolomite and liquid steel is insignificant, so it is possible to maintain very low level of oxygen in steel. The cleanliness of steel depends on low impurities in steel in the form of sulphide and low amount of O_2, N_2, H_2, C etc [17].

Therefore, dolomite was found to be the appropriate refractory for producing low oxygen steel. Due to different atmosphere in different zones of AOD convertor, zonal lining concept is adopted as shown in Fig 1. Maximum wear occurs in tuyere and belly area, which are subjected to high temperature and molten metal turbulences. Therefore, heaviest wear occur in these areas. Fired magnesia-enriched dolomite is used in these zones due to its better corrosion property. The top cone area and bottom is lined with carbon bonded or fired dolomite bricks. The properties of zone wise refractories are illustrated in Table III, which reveals that fired mag-dolo has superior properties compared to fired dolomite. The carbon bonded products will not be detrimental regarding the carbon pickup in steel, if proper oxygen injection is provided to decarburize the steel.

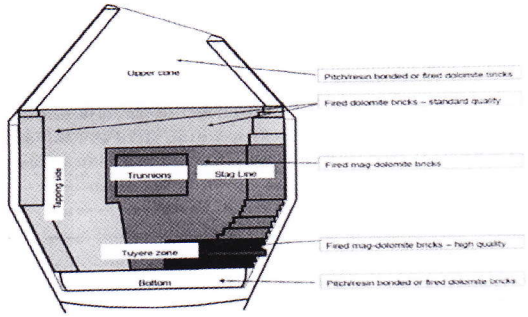

Fig. 1: Refractory lining in AOD converter [18]

Properties	Tuyere area	Belly portion	Top cone	
MgO, %	63.2	62.5	57.2	42.1
CaO, %	34.8	35.7	40.8	55.7
Apparent Porosity, %	14.0	14.0	14.5	14.0
Bulk Density, g/cc	2.90	2.90	2.88	2.85
Cold crushing strength, kg/cm^2	600	680	610	600
Refractoriness Under Load,(t_a °C)	>1700	>1700	>1700	>1700

Sathiyakumar et. al. [19] reported that in AOD vessel life is limited due to shrinkage of dolomite bricks in the critical areas, which allows molten metal penetration in the joints and wear the refractory. Additives like Nano Fe_2O_3, Cr_2O_3 and ZrO_2 controls the shrinkage of dolomite bricks. For Fe_2O_3 and ZrO_2 combined additive, nano Fe_2O_3 in the matrix enhances $CaZrO_3$ formation. Cr_2O_4. However, each additive beyond 1 wt. % is not effective. These additives will control the permanent linear change near to zero level.

Table IV. Composition and properties of Dolomite Refractory [19]

		MD 0	MD2	MD4	MD6
Composition	Sintered Dolomite	85	85	85	85
	Fused Magnesia	15	15	15	15
	Nano-Fe_2O_3	--	xxx	x	--
	ZrO_2	--	xxx	xxx	--
	Cr_2O_3	--	--	--	xxx
	Wax	2	2	2	2
Properties	Bulk Density, gm/cc	2.93	2.99	2.96	2.94
	Apparent Porosity, %	13.2	11.2	12.2	12.9
	PLC, %	-0.34	-0.32	-0.09	-0.07

Conclusions

Dolomite is long being used as a versatile refractory material for steelmaking. Its application has been shifted with the changes in primary steelmaking process from Bessemer converter to LD Converter and now it is used as a prime refractory for stainless steel making.

Stabilised / semistabilised dolomite was used initially for Bessemer Converter to convert lime to its silicate phase to stop hydration. However, due to the poor corrosion resistance of silicate phase, dolomite was sintered at high temperature for making tar / pitch bonded dolomite / mag-dolo bricks for LD Converter. Sintering of dolomite can be enhanced by adopting two stage process as oxides derived from hydroxides are highly reactive and favours densification. Fe_2O_3 in nominal amount also activates sintering through creation of cation vacancy in periclase as well as forming dicalcium ferrite with CaO phase thus favours both solid state and liquid phase sintering. Tar bonded Magnesia enriched dolomite blocks have relatively superior properties comparable to dolomite blocks in terms of density, hydration and corrosion resistance.

Fired dolomite and mag-dolo bricks replaced direct bonded mag-chrome is stainless making due to its exceptional thermodynamic stability in reducing and vacuum atmosphere. The shrinkage of fired dolomite bricks is controlled by using certain amount of additives like Fe_2O_3, Cr_2O_3, ZrO_2 etc., which ultimately minimize metal infiltration through brick joints.

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9. An abstract of the paper containing important feature of the text should be sent in about 100 words, along with the paper.
10. Five reprints of each paper shall be supplied to the author, free of charges.

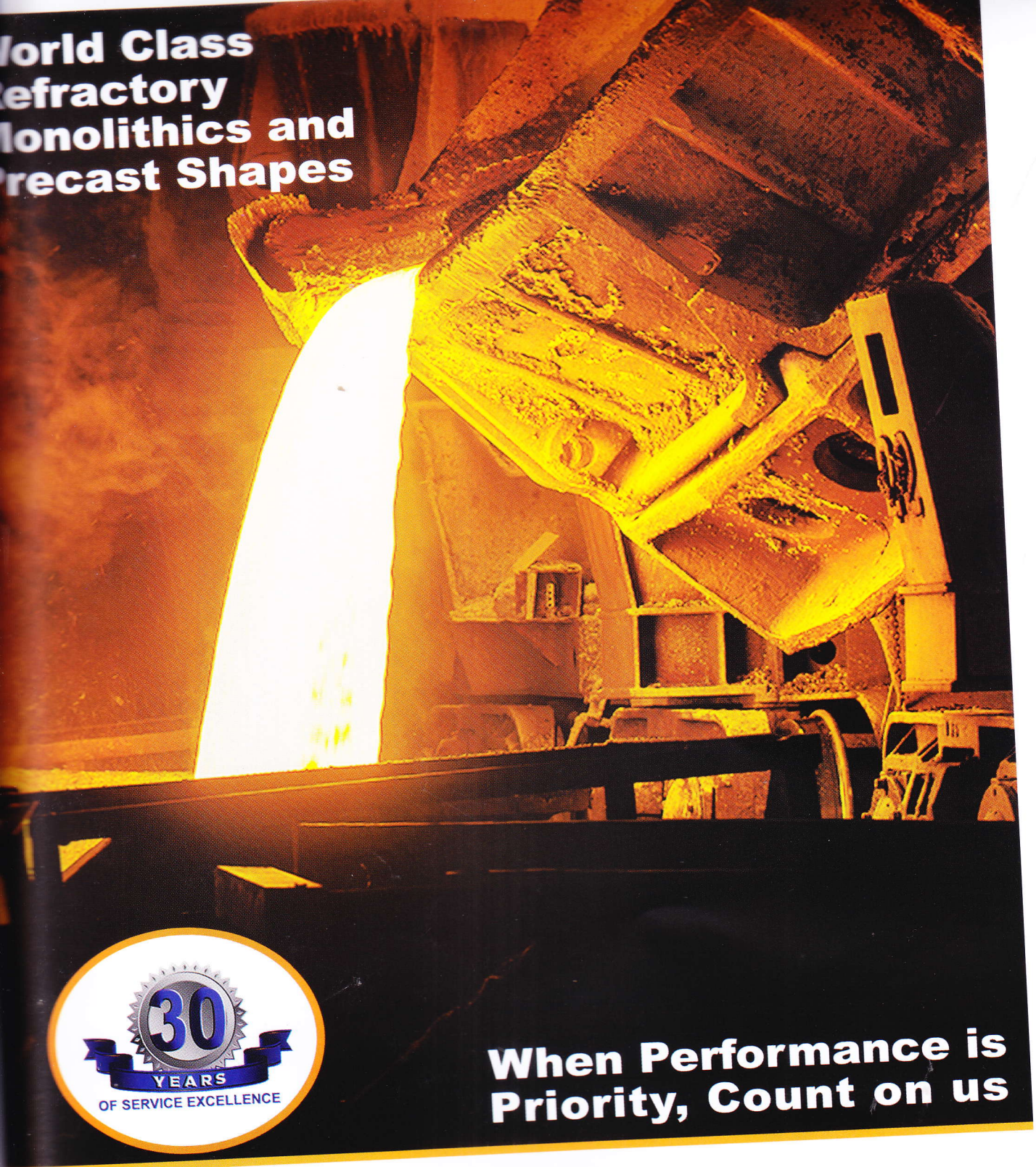
STATISTICS

India's Magnesite Import Data

Value in Rs '000)

Ore/mineral	Unit	2017-18		2018-19		2019-20(P)	
		Quantity	Value	Quantity	Value	Quantity	Value
Magnesite : Total	**tonne**	**229628**	**5268655**	**464367**	**11120844**	**365054**	**9468162**
Magnesia (Fused)	tonne	16320	1049128	21130	1630685	16325	823312
Magnesite (Not Calcined)	tonne	63048	219645	115540	390976	63874	185152
Magnesite (Calcined)	tonne	35059	930629	36157	1542203	50568	1645694
Magnesite:Dead-Burnt							

(Source: Indian Bureau of Mines)



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