ISSN 0250- 5304

IRMA JOURNAL

(for Private Circulation Only)
Volume LVII, No. 4, December 2024

Quarterly Journal Of Indian Refractory Makers Association

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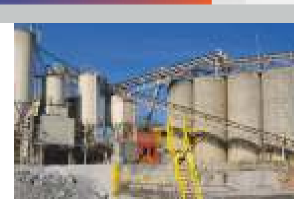
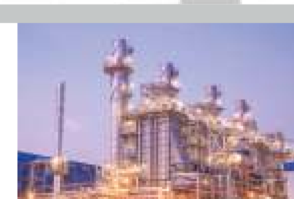

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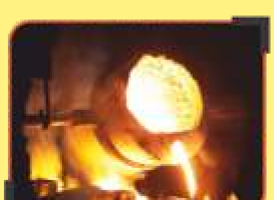

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Vol. LVII, No. 4, December 2024

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MESSAGE FROM THE CHAIRMAN

Dear Colleagues,

It is said that Olympics is the greatest show on Earth. It won't be gainsaying to state that IREFCON is one of the greatest shows of global refractory industry. And wow!! What a week it was! I hope you had as much fun attending as we did in organizing it. From the thought provoking lectures to the vibrant CEO panel discussions,, it was truly a festival to remember. For three consecutive days, the sea of participants absorbed knowledge from the best known minds of global refractory industry, networking with raw material suppliers, technology providers and making the best of the entertainment moments. In short India has occupied the centre stage of global refractory industry because of the immense opportunities it offers. .

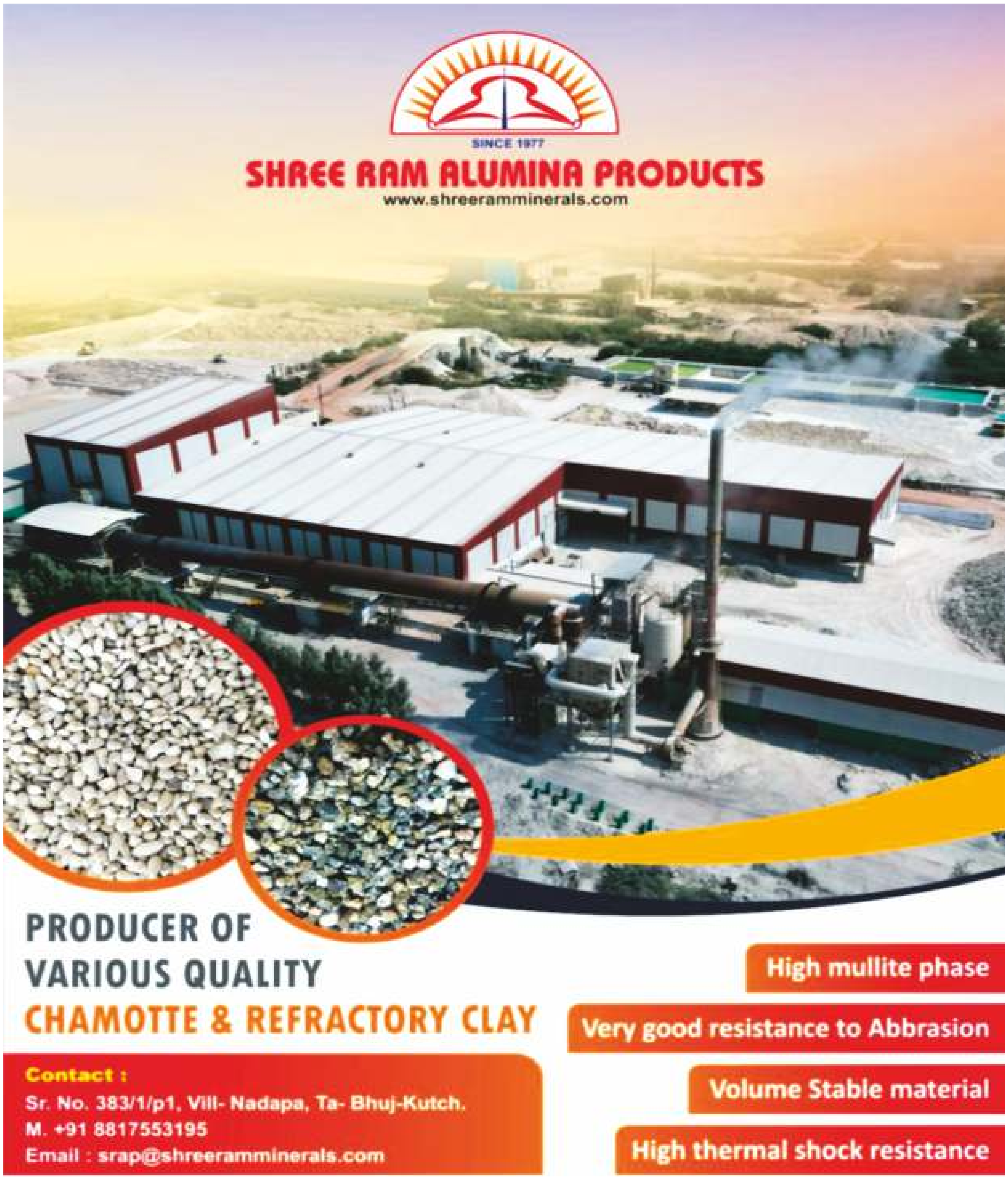
At the same time, we appreciate the commitments that you have shown towards IREFCON as sponsors, exhibitors, speakers, session chairmen or delegates, and truly appreciate the time you dedicated to joining us. The energy, optimism, and engaging approach displayed by each one of you were much appreciated and added to the event's unforgettable quality.

The theme of the congress was "Powering A Greener Future Together." True to the spirit of the theme, it provided access to the latest developments in sustainability, energy, and environment, offering valuable insights and knowledge to help usmake the world a tad greener. I was particularly amazed to learn the various green initiatives taken by fellow members of refractory fraternity. This shows the firm commitment of our industry to meet the present needs of our users without compromising the future of our progeny.

IREFCON24 is now part of history but its memories will remain etched forever in our hearts. We look forward to welcoming you back at IREFCON26 and extending our partnership with you.

Thanking you, one and all

Sunanda Sengupta
Chairman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ASSOCIATION ACTIVITIES

IRMA Board of Directors Meeting

IRMA Board of Directors meeting was held on 13th December 2024 under the chairmanship of IRMA Chairman Mr Sunanda Sengupta in Zoom platform. The issues discussed were review of market conditions, plans for IREFCON26, review of market conditions, future activities of IRMA, data collection etc.

IN THE NEWS

Demand for Steel in India

India will continue to outpace other major steel-consuming economies in calendar year 2025 with a demand growth of 8-9 per cent, CRISIL's Market Intelligence and Analytics report said. This demand will be driven by a shift towards steel-intensive construction in the housing and infrastructure sectors along with better demand from engineering, packaging and other segments, the report added.

The report, however, highlights that the domestic supply will remain a "point of concern", adding that the demand is estimated to have increased by 11 per cent in India.

ArcelorMittal Nippon Steel

ArcelorMittal Nippon Steel India is set to commission two production lines at its Gujarat-based facility this year to produce advanced automotive steel products. The company, a joint venture between ArcelorMittal and Nippon Steel, said that once operational, the production of the two units will substitute imports of high-end steel required by the entire automotive sector, promoting 'Atmanirbhar Bharat' initiative.

JSW & POSCO

JSW Group, one of India's fastest-growing conglomerates, has signed a Memorandum of Understanding with Korea's POSCO Group, outlining a framework for collaboration in steel, battery materials, and renewable energy sectors in India.

Demand for Cement

The cement demand is expected to remain strong in coming years with a growth of 7-8 per cent CAGR (compound annual growth rate) over FY25E-27E according to a report by JM Financial.

The report stated that after a brief slowdown anticipated in FY25E, the sector is expected to witness strong growth, driven by positive demand fundamentals and structural changes within the industry. "Demand for cement is expected to remain strong, particularly after a breather in FY25E, with key demand drivers looking positive and the sector poised for 7-8 pc CAGR over FY25E-27E" said the report.

India becomes first nation to define 'Green Steel'

India became the first country in the world to define "green steel" - emissions lower than a 2.2 per tonne of carbon dioxide per tonne of finished steel produced - while announcing a "star-rated grading system for such green steel". A nearly 37 per cent public procurement of these "costlier offerings" has been suggested to push manufacturing and aid adoption of the technology switch-over. As per the steel ministry, Green Steel has been defined in "percentage of greenness of the steel", which is produced from the plant with carbon dioxide equivalent emission intensity of less than 2.2 tonnes of carbon dioxide emission (CO_2 e) per tonne of finished steel (tfs).

The star rating system so introduced is also on the basis of "this greenness". For instance, the best quality steel which has a five star rating will have an emission intensity lower than 1.6t-CO_2e/tfs; a four star rating will be for steel with emission intensity between 1.6 and 2.0t-CO_2e / tfs; while a three star rating will be for emission intensity between 2.0 and 2.2 t-CO_2e/tfs/.

OVERSEAS NEWS

RATH

The international refractory manufacturer RATH has been developing continuous oxide ceramic fibers as part of the HORIZON EUROPE project InVECOF (Innovative Value Chains for European Ceramic Oxide Fibers) for several years. A production plant for the manufacture of innovative oxide ceramic fibers has now been commissioned at the RATH Mönchengladbach site (Germany).

Shinagawa Refractories

Shinagawa Refractories, the leading global supplier of refractory solutions, has announced that it has established Shinagawa Refractories China in Jinan, Shandong Province, People's Republic of China.

RHI Magnesita

RHI Magnesita has announced a long-term strategic partnership with Capgemini, a global business and technology transformation partner. This collaboration marks an important milestone in RHI Magnesita's transformation journey in terms of internal Shared Services through innovation, operational excellence, and digitalization.

The company has also introduced "4PRO" – a new refractory solutions contract model. The transformative business model is designed to lead high-temperature industries like steel, cement, glass, non-ferrous metals etc. towards a sustainable and technologically advanced future through a more holistic and contemporary approach. Each solution category – from Sustainable Products and Robotics to Systems, Sensors, and Digital Solutions – has been designed to deliver tangible performance benefits while contributing to sustainability and operational excellence.

Refratechnik and RATH

Refratechnik and RATH have announced the launch of a long-term technology alliance. As part of the technology alliance, both companies will contribute their respective know-how in glass manufacturing and refractory production to combine it into a unique technology solution. The two companies will be operating under the name "R^2 – THE GLASS FURNACE ALLIANCE." RATH will be the main point of contact for customers seeking the best mix of Refratechnik and RATH products for glass melting furnaces.

Appointment

Dr. Rainer Gaebel, Managing Director of Refratechnik Holding, has been elected President of the World Refractories Association with effect from 14th November 2024. He succeeds Parmod Sagar, MD & CEO of RHI Magnesita India, who was elected President of the WRA in March 2022.

MEMBERSCAN

Carborundum Universal Ltd

Carborundum Universal Ltd has signed a binding share purchase agreement to acquire a 100 % stake in Silicon Carbide Products, Inc USA (SCP) from its current equity shareholders. The deal values SCP at an enterprise value of USD 6,66 millions. CUMI plans to establish a wholly-owned subsidiary in the US, which will serve as the Special Purpose Vehicle (SPV) for this acquisition.

TRL Krosaki Refractories Ltd

TRL Krosaki has laid the foundation stone for its new Refractory Manufacturing Unit at Gujarat near Samakhiyali on 21st January 2025.

The plant will manufacture both High Alumina Bricks and Monolithics. The foundation stone was laid by Mr. H M Nerurkar, Chairman, TRL Krosaki in the presence of Mr. P K Naik, Managing Director.

Vesuvius India Ltd

Vesuvius India Ltd has inaugurated the new Alumina-Silica (AlSi) and Basic Monolithic manufacturing plants, at a ceremony held on 12th November 2024, in Visakhapatnam, further supporting the Make in India initiative. The new AlSi and Basic Monolithic plants will produce high-quality alumina-silica and basic monolithic refractory products, essential for iron and steel production. This expansion, once in commercial production, will boost annual production capacity by 250,000 tons.

OBITUARY

Dr. Arup Kumar Chattopadhyay, former IRMA Chairman (2006-2010) peacefully passed away on 13th January 2025. He was an M. Tech in Chemical Technology – (Specialization in Ceramic Tech) & completed his Ph.D. (Tech) from Calcutta University. Dr. Chattopadhyay was conferred with 'Distinguished Life Member of Unified International Technical Conference on Refractories (UNITECR)' for his contribution in the field of refractories.

He had a rich and coveted experience of more than 46 years in leading refractory industries like dalmia refractories, acc-refractories division (now calderys india refractories ltd.), TRL Krosaki (formerly managing director of TATA refractories limited) in various business functions & was pioneer in introducing innovative products/services which helped the organizations to achieve phenomenal growth under his stewardship. May his soul rest in eternal peace.

ECONOMY AT A GLANCE

- A weaker manufacturing sector and slower corporate investments are seen dragging India's growth to 6.4% in 2024/25, the slowest pace in four years.
- Private investment is seen rising by 6.4% in 2024/25, lower than 9% growth in the previous year, while consumption, which accounts for nearly 58% of GDP, is estimated to expand by 7.3% year-on-year compared to 4% in the previous fiscal year.
- Weak growth in wages has impacted discretionary spending of urban middle-class Indians, according to large consumer companies on their quarterly earnings calls, even as rural demand has improved due to a strong monsoon in 2024.
- India's retail inflation in December eased to a four-month low of 5.2%, raising hopes the country's central bank would start cutting interest rates in February. But inflation in food items, which account for nearly half of the consumption basket, continued to remain high at 8.39% in December, with vegetable prices rising at an eye-watering pace of 26.56%.
- Govt. of India is looking to contain its fiscal gap under 4.9% for 2024-25 as initially targeted, and aims to bring it down below 4.5% in the next financial year. The country's fiscal gap had ballooned to 9.3% in 2020-21 during the pandemic.
- From 2026-27, the country will move away from targeting the fiscal deficit and prioritise lowering India's debt-to-GDP ratio. The general debt-to-GDP ratio, that includes state government debt, is estimated at 82.6% in 2024-25, according to the IMF.
- Net foreign direct investment between April and November 2024 in the current fiscal year stood at $479 million, according to data from the Reserve Bank of India (RBI), a sharp fall compared with a net inflow of $8.5 billion a year earlier. Repatriation of funds and outbound investments have weighed on net inflows, the RBI said in its January economic bulletin.

BUSINESS SECTION:

15TH INDIA INTERNATIONAL REFRACTORIES CONGRESS (IREFCON '24): A REPORT

IREFCON 24

IREFCON 2024 was organized from 13th-15th November 2024 at Taj Cidade de Goa, Horizon, Goa.

The theme of the congress was powering a greener future together.

The curtain raiser began on 13th November, 2024 evening along with a power talk by Ms. Priya Kumar and a plenary talk titled: "A sustainable refractory industry in a new, changed world" by Mr. Stefan Borgas, CEO, RHI Magnesita. The evening ended with an interactive session titled "Women in Refractories" to acknowledge the contribution of women in the growth and development of refractories industry.

The inauguration program on 14th November, 2024 began with IREFCON'24 Organizing Committee Chairman, Mr. Sunanda Sengupta's welcome address. He thanked all the participants for making IREFCON 2024, a grand success and while pointing out the growth curve of Indian refractory industry. The signature CEO event was moderated by Mr. Sunanda Sengupta and Mr. Jyotirmoy Bhattacherjee.

The **CEO panellists** were as follows:-

- Mr. Patrick Andre (Vesuvius PLC)
- Mr. Stefan Borgas (RHI Magnesita N.V.)
- Mr. Egawa Kazuhiro (Krosaki Harima Corporation)
- Mr. Ish Mohan Garg (Calderys India Refractories Limited)
- Mr. Heiki Miki (Shinagawa Refractories Co., Ltd.)
- Mr. Vishal Agarwalla (Maithan Ceramics Ltd)
- Mr. Rainer Gaebel (Refratechnik)
- Mr. Saurabh Khedekar (Hindalco Industries Ltd)
- Mr. Rajendra Pathak (Jindal Stainless Limited)

The Keynote Speeches and Theme lectures were spread out over 14th and 15th November, 2024 where issues ranging from sustainability to recent advancement in refractories technology were discussed in details.

Keynote Speakers	Organization
• Dr. Atul Vaidya	• National Environmental Engineering Research Institute (NEERI),Nagpur
• Dr. Atanu Ranjan Pal	• Tata Steel Ltd
• Dr. Anjan Kumar Chatterjee	• ConmatTechnologies
• Dr. Helge Jansen	• Refratechnik Steel GmbH

The **Theme lecturers** were as follows:-

Theme Lecturers	Organization
• Mr. Azim Syed	• RHI Magnesita
• Mr. Danilo Bomfim	• Shinagawa Brazil
• Mr. Marcel Peekel & Mr Hein van der Velden	• Tata Steel Netherlands
• Ms KopalAgrawal	• Hindalco Industries Ltd
• Mr. Mike O'Driscoll	• IMFORMED Industrial Mineral Forums & Research Ltd

Overall 32 case studies were presented at the event highlighting collaborative efforts between raw material suppliers – refractory makers and refractory makers - Steel industry.

The participating companies were as follows:-

- Adani cement
- Almatis Alumina Pvt Ltd
- Arcelor Mittal Refractories
- Brahma Refractories Pvt Ltd

The Sponsoring companies were as follows:-

Type of Sponsors	Organization
• **Title**	• Vesuvius India Ltd
• **Cultural Night**	• RHI Magnesita India Ltd
• **Bar Sponsor**	• Maithan Ceramic Ltd
• **Welcome Dinner**	• TRL Krosaki Refractories Limited
• **Diamond**	• Calderys India Refractories Ltd • Almatis Alumina Pvt Ltd • Hindalco Industries Limited • IFGL Refractories Ltd • Aarya Metallurgicals (India) Private Limited
• **Platinum**	• Refratechnik (India) Private Limited • Global Monarch FZC-UAE • Sarvesh Refractories (P) Ltd. • Elkem South Asia Pvt Ltd
• **Gold**	• Orind Special Refractories (P) Ltd • Vishva Vishal Refractory Ltd • Totale Global Pvt Ltd • Shinagawa Refractories India Private Limited • Imerys • Mahakoshal Refractories Pvt Ltd • Carborundum Universal Limited
• **Silver**	• 4S Refractories Pvt Ltd • Noble Refractories • F G K Thermal Pvt Ltd • Murugappa Morgan Thermal Ceramic Ltd • Vishwakarma Refractories Private Limited
• **Tea/Coffee**	• Jai Balajee Trading Company

IREFCON 2024 exhibition generated huge response with spontaneous participation of number of raw material producers, equipment manufacturers and other service providers.

IREFCON 2024 exhibition generated huge response with spontaneous participation of number of raw material producers, equipment manufacturers and other service providers.

The **Companies participated** in the exhibition were as follows:-

- Aarya Metallurgicals (India) Private Limited
- Adithya Power Refractories and Insulation Private limited
- Amity Resin
- Arcum Engineering (P) Limited
- Autosys Engineering Pvt Ltd
- Bharat Minerals Industries
- Carborundum Universal Limited
- CCRT Laboratories
- Ceramics International
- Ceraref Private Limited
- Çimsa Cement
- Cremer Erzkontor GmbH & Co. KG
- Eirich India Pvt. Ltd.
- Forace Specialty Chem Pvt Ltd
- Fused Minerals Industries LLP
- Gautam Zen International Pvt Ltd
- Global Monarch F.Z.C.
- Global Recycling
- Hindalco Industries Ltd
- Imerys Vizag Pvt. Ltd.
- Indaid Engineers Private Limited, Chennai
- ISGEC Heavy Engineering Ltd
- ITOCHU Ceratech Corporation Japan
- Kanoria Chemicals & Industries Ltd
- KPL International Limited
- LAEIS GmbH (Luxembourg)
- Lanexis Enterprises Private Limited
- MEL Systems and Services Ltd.
- Minchem Impex India Pvt Ltd
- Neptune Industries Limited
- NY2 Global Business Pvt Ltd
- Orient Ceratech Limited (Ashapura Group)
- Pennekamp Middle East (L.L.C)
- Precision Drawell Pvt Ltd
- Raghuvanshi Refractories
- Refsol Marketing Pvt Ltd
- Romco Aluminates Pvt Ltd
- SACMI IMOLA S.C. (Italy)
- Shree Sadashiv Refractories Pvt Ltd
- Saint-Gobain Grindwell Norton Limited
- Shree Ram Alumina Products
- Steel & Metallurgy
- Thyme India Pvt Ltd
- Zibo Sangde Machinery Equipment Co. Ltd.
- Zircar Refractories Limited

The award winners of exhibition were:-

- Hindalco Industries Ltd (Best exhibition stall)
- Imerys (Second best exhibition stall).
- Orient Ceratech Limited (First runner-up exhibition stall) .
- Arcum Engineering (P) Limited(Second runner-up exhibition stall.

Overall 707 delegates from India and abroad participated in the Congress.

Raw Material Supplier	Equipment Manufacturer
194	36
Refractory Maker	**R&D Bodies**
371	3
User Industries	**Others**
52	51

PHOTO GALLERY

Curtain Raiser Session at IREFCON '24

Curtain Raiser Session at IREFCON '24


Section of the Delegates

Lecture Sessions

Lecture Sessions

Sponsor Signage

View of Exhibition Area


View of Exhibition Area

PHOTO GALLERY

Address by the Chief Guest, Mr. Sanjay Singh

Honouring immediate past Chairman of WRA, Mr. P. Sagar

Section of the Delegates

Women in Refractory Industry

Award giving ceremony

CEO Meet

Glimpse of Cultural Program

Glimpse of Cultural Program

TECHNICAL SECTION

TOWARDS A GREENER FUTURE: A REVIEW OF TECHNOLOGICAL INNOVATIONS FOR DECARBONIZING THE IRON AND STEEL INDUSTRY

Authors: Atanu Ranjan Pal, Sabuj Halder,Goutam Kumar Raut Tata Steel Ltd

1. Abstract

The Indian steel industry accounts for about 12% of Indian carbon dioxide (CO_2) emissions, with an emission intensity of 2.5 tonnes of CO_2/tonne of crude steel (tCO_2/tcs) compared with the global average emission intensity of 1.85 tCO_2/tcs. Indian steel industries are responsible for around 250 MT of CO_2emissions/annum and will be twice by 2030.Therefore, to cope with the global crisis of climate change, the Indian Govt has set a target to achieve net zero emissionin steel sector by 2070.

To meet future CO_2 emissions targets, the steel companies are developing strategies for adopting clean ("green") energy technologies while at the same time trying to maintain their competitiveness in the marketplace. This paper highlights the technology pathways that could help in the transition from traditional methods to low emission intensity technology like - Direct Reduced Iron (DRI)-Electric (ESF), EASyMelt etc.

2. Introduction

As global concern over climate change is increasing, the industry is facing a pivotal moment that will require a drastic change in the way it operates. Today's steel industry uses two primary process routes: the Blast Furnace (BF) to Basic Oxygen Furnace (BOF) integrated route converting iron ore into steel, and the scrap based Electric Arc Furnace (EAF) mini-mill route. The dominant BF-BOF route, accounting for 71% of global steel production, emits two to seven times more greenhouse gases than the EAF route.EAF can be solution to reduce CO_2 emissions by more than 75%, however is constrained by the availability of scrap in developing nations. To achieve future emission targets, most companies are now directing their focus on reducing CO_2 emissions through various enablers which are discussed below:

1. Makeshiftenablers – emission reduction potential < 25%
   - Use of Coke Oven Gas/Natural Gas/ H_2 in BF.
   - Use of Biochar in BF PCI, sinter etc.
   - Use of Scrap in BOF.
2. Retrofit enablers – emission reduction potential > 25%
   - Use of recycled gas in blast furnace for injection/Electrical Heating.
3. Transformationalenablers – technology transformation-emission reduction potential>50%.
   - Electrowinning
   - H_2- DRI
   - Molten Oxide Electrolysis

These different initiatives / technologies along with their CO_2 emissions reduction potentials are shown in Fig. 1.

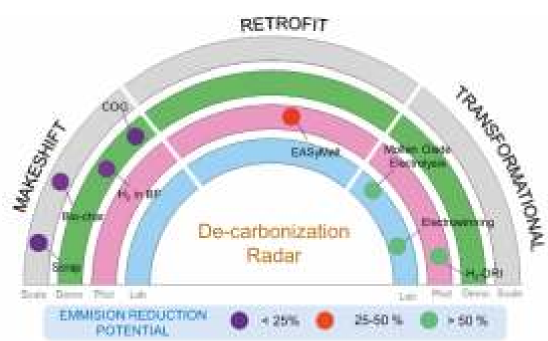

Figure 1. Carbon Direct Avoidance

While some of these technologies are make-shift in nature with minimal changes to the structure and design of the incumbent blast furnace configuration, few such as EASyMelt require significant retrofits to the blast furnace and its ancillary equipment. Others such as hydrogen-based DRI, molten-oxide electrolysis and electro winning present a departure from the existing blast furnace route for iron production including a complete overhaul of the underlying process principles and design. An illustration of these aspects can be seen in Fig.1 wherein, technological enablers and their CO_2 abatement potential is mapped along with their technology readiness level (TRL).

2.a. Makeshift enablers to reduce the CO_2 emission by up to 25%

'Make-shift' initiatives such as promoting greater scrap usage in BOF steelmaking and injection of H_2-bearing feedstocks such as bio-char, coke-oven gas, natural gas and hydrogen into existing commercial blast furnaces are being actively pursued by steelmakers across the globe. While these interventions do not require significant structural modifications to the blast furnace and its ancillary equipment, the extent of achievable CO_2 reduction (< 25% of the current CO_2 intensity) is limited to the extent of replacement of the conventional fossil fuels - coke and pulverized coal with these H_2-containing or carbon-neutral injectants. The replacement ratio of fossil carbon by bio-carbon or H_2 is a function of the extent of utilization of bio-carbon and H_2 within the blast furnace, which is limited by inherent aspects of the BF process such as the FeO/Fe equilibrium considerations and the lack of top gas recycling. Further, due to the sheer significance of coke in the blast furnace process towards dictating the gas distribution and liquid permeability in the stack and hearth regions respectively while providing mechanical support to the overlying burden column, the BF will continue to rely on a minimum quantity of coke in the foreseeable future irrespective of the improvements in fossil carbon replacement through renewables or hydrogen. In other words, it would be a formidable challenge to achieve net-zero with current BF-BOF assets without a means to capture and sequester/utilize the CO_2.

Of the different technologies in this 'make-shift' segment, enhanced scrap usage in the converters is being regularly practiced at several BF-BOF plants. SSAB group, Arcelor Mittal and Tata Steel have also tried to supplant a part of their fossil carbon with bio-char injection at their blast furnaces plants where bio-char is available. COG injection in BFs is being commercially exploited at several steel plants such as US Steel Mon Valley works -USA, ArcelorMittal Asturias - Spain, ROGESA - Dillinger Hüttenwerke & Saarstahl AG – Germany etc. H_2 injection in BFs has only been tried at a demonstration scale at ThyssenKrupp AG - Germany, Tata Steel - India and Cleveland Cliffs – USA through one or multiple tuyeres. At the present cost of green hydrogen, carbon taxation and trade policy frameworks, it is not economically viable for large-scale deployment of H_2-injection in BFs. This is expected to change in the coming years with new electrolyser capacities, cost reduction of renewable energy, electrolyser technology improvements and enforcement of aggressive regulatory compliance norms along with carbon pricing frameworks.

2.b. Retrofit enablers to reduce the CO_2 emission by up to 50%

CO_2 capture, either from the BF-top gas (ULCOS top gas recycling BF) or stove flue gas and recycling of hot reducing syngas (CO & H_2 molecules) through the tuyeres and lower shaft of the BFs is a promising technical approach to improve the gas utilization of CO and H_2 and lower the pressure drop in the BFs. The hot reducing syngas can either be generated in an external reformer or be the product of the BF top gas stream post CO2-stripping. Furthermore, meeting a part of the process energy requirement with energy from renewable electricity such as plasma is further expected to lower the dependence upon fossil carbon.

The EASyMelt technology from SMS, based on the underlying principles of shaft and tuyere injection of hot syngas and CO_2 capture from flue gas from external reformer stoves with plasma energy input, aims to lower BF coke rates and carbon emissions dramatically (by 25 to 50% of current CO_2 intensity levels). However, adoption of these technologies requires significant retrofits to the blast furnace structure such as provisions for lower shaft injection of the hot reducing gas, designing of advanced reformer chambers for effective syn-gas conversion and development of reliable high capacity plasma systems to provide the necessary thermal boost to such substantial gas volumes injected through the tuyeres and the lower shaft. As a result, technologies based on this approach have so far been tried only at a pilot scale and are expected to follow the progressive upscaling trajectory prior to full-scale commercial deployment. These segment of technologies, in a way, establishes the maximum possible CO_2

abatement possible through the BF-BOF route. It is to be noted that despite the significant reduction in carbon emissions, the BF will still require a minimum quantity of coke to support the overlying burden and maintain proper gas flow.

2.c. Transformational enablers to reduce the CO_2 emission by more than 50%

To be able to reduce the ironmaking carbon footprint dramatically (by > 50% of current CO_2 intensity levels) without CCUS, a complete paradigm shift is necessary as depicted towards the right side of the radar plot. This would imply eliminating or minimizing both direct as well as indirect carbon usage in the ironmaking processes and rely on other energy forms that can deliver the energy required at various stages of the ironmaking value chain. This includes the likes of using green H_2 or green fuels or renewable electricity both in the upstream raw material preparation processes and ironmaking and thus, calls for a complete transformation of the current BF-BOF production setup including substitution of blast furnaces with different process reactors. Several steelmakers such as SSAB, ArcelorMittal, Voest-Alpine Stahl etc. have already announced programmes to leverage H_2-based DRI to achieve their decarbonization goals. Pilot trials are underway (HYBRIT project) in Sweden where fossil-free electricity is being used to produce green H_2, which is subsequently used to produce fossil-free DRI in a shaft furnace. Electrochemical technologies such as electrowinning and molten-oxide-electrolysis have also demonstrated the feasibility of iron production from iron-ores. Boston Metals, a spin-out from MIT, has set up a facility in Brazil to commercialize the Molten Oxide Electrolysis (MOE) process to reclaim valuable metals from mining waste. It has also set up a prototype MOE reactor to produce green steel at Woburn, Massachusetts, USA. Both these electrochemical process technologies produce O_2 as a by-product instead of CO_2. They rely on redox reactions under different conditions to isolate the iron from the oxygen in the ores. While electrowinning utilizes highly alkaline aqueous solutions to dissolve the crude iron-ore, MOE utilizes a suitable electrolyte and very high currents to achieve high temperatures (~ 1600°C) within the cell to effectively dissolve the iron-ore and reduce it to molten iron. Large scale commercial adoption of these technologies would require investments not only in upscaling, but also in terms of land usage due to the modular nature of the MOE electrolytic cells.

However, none of this technology is expected to bring the integrated steel production route to a net carbon zero level. Instead, the steel industry is placing its bets on a suite of decarbonization technologies that would contribute towards this energy transition. Adoption of such a strategy is necessary as the CO_2 abatement potential of each of these enabling technologies and their scalabilities are markedly different from one another.But, due to higher CAPEX involved in technological transformation, lack of financial support from the government, and lack of clarity in government policies, EAF is gaining popularity over BOF's due to itsversatility, cost-effectiveness, and environmental advantages.

3. Different steel making routes and their decarbonizationpotential-Best alternative technology for decarbonisation:

Different steel making routes with their total CO_2emission (tCO_2/tCS) is shown in Figure.2. Currently, Route-II accounts for more than 70% of the global steel production. To reduce the carbon emission below 1.5 tCO_2/tCS, EAF is preferred over BOF.

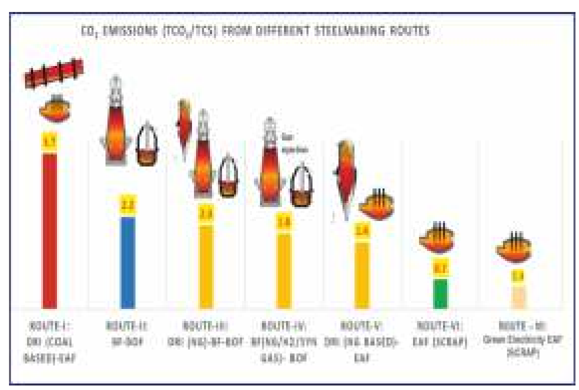

Figure 2.CO_2 emissions for from different steelmaking routes

3.a. Electric Arc Furnaces (EAF)

Though EAF primarily uses scrap metal as the main raw material but can also utilise DRI/HBI or pig iron.Hence, EAF doesn't rely only on iron ore as the BOF, which makes it highly versatile. Due to its ability of utilization ofrecycled steel and renewable energy, EAFs have much higher potential for decarbonization.Hence, EAF is more aligned towards future sustainability goals and carbon reduction initiatives. In almost all scenarios, The EAF process has lower carbon emission than BF-BOF process as given below.

- DRI + Scrap emits an average of 0.7 tCO_2/tcs(with renewable power emission this can reduce to 0.4 tCO_2/tcs).
- DRI(NG based) + EAF emits an average 1.6 tCO_2/tcs(including CO2 emissions from the pellets).
- BF-BOF emits an average of 2.2 tCO_2/tcs.

As the world is moving towards more sustainable and environmentally friendly practices, many companies are investing in EAF technology. Countries and companies that aim to meet climate targets and to reduce their carbon footprint find EAF as a critical part of their transition towards greener steel production.

3.b. DRI – Electrical Smelting Furnace - BOF

Quality of the DRI is determined by the grade of pellet used. High quality DRI is obtained by utilising DR-grade pellets, whereas low quality DRI is obtained from the BF-grade pellets(Refer Table.1 for quality of typical BF-DR grade pellet available in the market).Based on the quality, DRIcan be utilized through different steel making routes for lowering the Carbon footprint.

1. Higher Grade DRI can be directly utilised in an Electric Arc Furnace (EAF) to produce steel.
2. Lower grade DRI requires smelting in an Electric Smelting Furnace (ESF) to produce Hot Metal (HM) / pig iron, which is then refined into steel in Basic Oxygen Furnaces (BOFs) or EAF.

High grade globally available DRI is processed in the conventional DRI-EAF route which utilizes various blends of DRI and scrap to produce steel. This flowsheet's effectiveness depends on the low gangue content of DRI made from DR-grade iron ore pellets.

However, low grade Indian DRI (higher gangue and lower Fe)which is made from BF grade pellets, leads to lower yield and higher slag losses at EAF. To cope with this situation, it's required to separate the slag prior to steel making. Hence, The DRI-ESF-BOF route is an emerging pathway aimed at utilising BF-grade pellets in a lower emission ironmaking process. In this pathway, BF-grade pellets are reduced to metallic iron in a shaft furnace and subsequently smelted in an ESF to produce carbon-containing HM (Refer Fig.3 and Fig 4). The HM can then be charged into existing BOFs to produce steel, making this process route appealing for BF replacement, while retaining oxygen steelmaking and downstream assets.

While replacing the BF the proposition is to divide the operation into two parts. The first part being the shaft-DR process. This process strongly resembles the top half of the BF in both form and function, where the iron ore descends downwards and is reduced by hot reducing gases rising from the bottom of the furnace. The second part being the ESF, which functions as the bottom half of the BF, where the partially reduced ore is reduced to Fe, melted, and carburized, to produce molten 'hot metal' and slag.

Table 1.Quality of typical BF-DR pellet available in the market.

Typical pellets available on the market*							
Chemistry		Blast Furnace pellets			Direct Reduction pellets		
		min	max	demand	min	max	demand
Fe_{total}	%	61	67		67	68	>67
SiO_2 Al_2O_3	% d.b	1.6 0.2	10 3		0.75 0.2	1.6 0.5	sum <2%
TiO_2	% d.b	0.01	0,04		0.01	0.15	<0,15
CaO MgO	% d.b	0 0	3.7 1.4		0.2 0.2	2 1.5	sum <3%
B2 CaO/SiO_2	-	0	1	<0.2 or >0.7			

Figure 3.The emerging DRI-ESF-BOF flowsheet

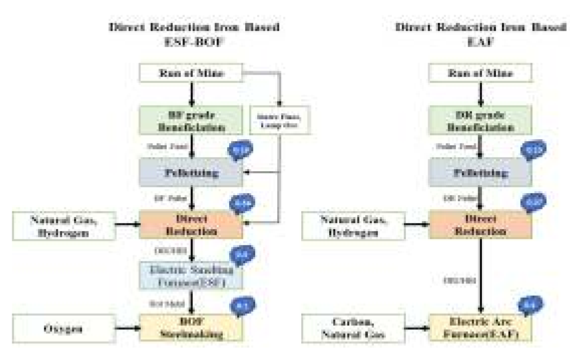

Figure 4. Electric Smelting F/c (ESF) vs Electric Arc F/c (EAF) Flow sheet with CO_2 Emission

Constraints in DRI-EAF process

In terms of Fe yield, the BF-BOF process demonstrates effectiveness in handling high gangue ores with the minimal Fe losses, contrasted to the DRI-EAF process which experiences more than 10% decrease in Fe yield owing to its FeO-rich slag. The ESF's reducing environment plays a crucial role in minimizing FeOcontent in the slag and enhancing Fe yield, thus establishing it as the preferred option for processing high gangue DRI.

These insights are discussedin Table 2, where the overall Fe yield is calculated from ore to metal forvarious process. The DRI-EAF route demonstrates the highest slag rate, attributed to its relatively high slag basicity targets. EAF slag becomes a low value-added waste due to its FeO content ~ 30%, stemming from the highly oxidizing environment of the EAF process. In contrast, the ESF method efficiently rejects gangue and diminishes slag rates, yielding commercially viable slag for cement industry applications akin to that of the BF process.

Table 2. Comparison of Total FeO loss in slag in various process

Parameters	Unit	Process Type						
Process Type		BF-BOF	ESF NG-DRI	ESF NG-DRI	EAF - NG- DRI	ESF H2-DRI	ESF H2-DRI	EAF - H2-DRI
			Off-gas recycle	Methanation		Off-gas recycle	Methanation	
Scenarios		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Slag Rate	kg/tcs	330	270	270	400	280	280	450
Fe Yield	%	94	92	92	86	92	92	86
CO_2 emission	t/tcs	2.05	1.15	1.07	1.21	0.5	0.43	0.5
Total FeOin Slag	kg/tcs	17	18	18	120	18	18	140

The BF-BOF emissions with respect to DRI – EAF, Scrap-EAF and Scrap-green electricity EAF are compared in Fig 5. It depicts a shift in CO_2 emissions, while switching from the BF-BOF route to the DRI-EAF route which is increasingly being preferred by most of the European steelmakers as they are planning towards lowering CO_2 emissions and carbon-taxes.

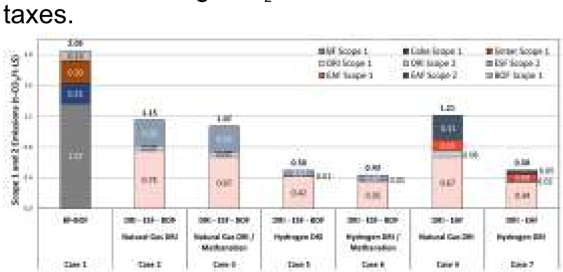

Figure 5. Estimated CO_2 emissions for selected flowsheets in Table 1.

4. CO_2 emissions contribution by refractory industry:

The refractory industry plays a substantial role in global carbon emissions due to its energy-intensive production processes and the high embodied energy of its raw materials. Fossil fuels are extensively used for firing, drying, and processing refractories, contributing significantly to CO_2 emissions. Additionally, the extraction, processing, and transportation of raw materials like alumina, silica, and magnesia release further amounts of CO_2. Manufacturing processes such as calcination, sintering, and fusion also generate CO_2 emissions.

Globally, the refractory industry produces an estimated 100-150 million tons of refractories annually, resulting in approximately 200-300 million tons of CO_2 emissions per year. This represents roughly 0.5-1% of total global CO_2 emissions.

Among refractory materials, fused magnesia and fused alumina have particularly high carbon footprints due to their energy-intensive production processes. Fused magnesia, for instance, has an average carbon intensity of 1.2-1.5 tons of CO_2 per ton of fused magnesia, leading to total emissions of 2-3 million tons per year. Similarly, fused alumina has an average carbon intensity of 2.5-3.5 tons of CO_2 per ton, resulting in total emissions of 5-7 million tons per year.

Fused magnesia is produced through a multi-step process that begins with the mining of magnesite ore. This ore is then calcined to produce magnesia (MgO), which is subsequently fused in an electric arc furnace to create fused magnesia. The carbon footprint of fused magnesia is primarily driven by the energy consumption during the electrofusion process.

Fused alumina, on the other hand, is produced through a more complex process involving bauxite mining, refining using the Bayer process, smelting through electrolysis, and finally fusing in an electric arc furnace. The carbon footprint of fused alumina is influenced by the energy consumption throughout these stages, particularly during the smelting and fusing processes.

Hence, refractory industry should also focus on reducing carbon footprint through implementation of sustainable production techniques and adoption of renewable energy.

5. Conclusion

As a promising steelmaking process, the DRI-ESF-BOF flowsheet shows great flexibility and ability to decarbonize the steelmaking value chain, using low gradeIndian iron ore. Through this route, recycling and methanation of off-gases reveals convincing opportunities for cost savings and emission reductions, making the ESF-BOF route competitive with traditional and emerging steelmaking methods. In the short to medium term, utilization of NG/H2 injection or hydrogen derived from methanation emerges as a key strategy for reducing Scope 1 emissions and enabling steelmakers to postpone transition to H_2-based DRI while still maintaining profitability. In the longer term, as governmental legislation on carbon pricing becomes stricter and transition to H_2-based DRI becomes necessary, the existing methanation unit will be available to mitigate the risk associated with low carbon DRI, thereby safeguarding sufficient carbon availability to sustain normal BOF operation.

It is interesting to point out that the initial euphoria in the steel industry related to the replacement of the BF/BOF route with hydrogen based DRI / EAF and DRI / Smelter / BOF technologies, has been considerably reduced due to high cost of implementation, lack of government funding and lack of clarity on massive infrastructure development. Therefore, most companies are now directly focusing on reducing CO_2 emissions at their existing plants by improving operational efficiency (including energy efficiency) and by adoption of selected mature technologies that are financially viable.

Refractory industry is also a major emitter and needs to focus on reducing carbon footprint through implementation of sustainable production techniques and adoption of renewable energy.

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(Source: IREFCON24 proceedings)

TECHNICAL SECTION

DEVELOPMENT OF SUITABLE SHOTCRETE MATERIAL TO ACHIEVE BETTER TECHNO-COMMERCIAL PERFORMANCE OF TORPEDO LADLE

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ABSTRACT

Over past decades, torpedo ladle has become very common and regular transfer vessel to transport hot metal from the blast furnace to the steel shop. Other than long residence time and transfer, this whole process also involves higher metal/slag turbulence and greater chemical attack. Thus, high quality refractory lining, such as Alumina Silicon Carbide based bricks are lined in torpedo ladle which should be used for long service life. Good degree of resistances against thermal shock, abrasion, impact, and wear resistances of refractory lining are perquisite. To prolong the working refractory lining life of the torpedo ladle, a suitable selection of shotcrete castable became necessary. The present case study describes the development of right quality of shotcrete castable which not only ensures extended service life of torpedo ladle working lining but also achieves techno-commercial requirements of its performance. The development targeted to meet better abrasion resistance, volume stability and strength parameters for the shotcrete material but also ensures desired flowability and optimization of setting time during application and more importantly lowest rebound loss and lower shotcrete material consumption. Final users' references are sighted to prove superior product development using appropriate Alumina based raw materials.

Keywords: Torpedo ladle, repair castable, shotcrete mass

INTRODUCTION

Torpedo ladle is an important vessel in the integrated steel plant, performing intermediate treatment (e.g. desulfurization), homogenization and transport activities in between iron making (blast furnace) to steel making (converter). The overall productivity increase thus also depends on the performance of torpedo ladle. Few decades before, hot metal ladle was popular and that is continuing today as well but effective only for small steel plant. Majority of integrated steel plants have converted their operation to torpedo ladle in last 2 decades to achieve better operational productivity. The major advantage in torpedo ladle over hot metal ladle is primarily capacity (torpedo 200 mt to 350 mt typically) vs hot metal ladle (50 mt to 150 mt typically) and refractory life, where as metallurgical treatment scope and temperature loss prevention in hot metal ladle is quite minimal. This also prevents usage of hot metal ladle for long distance movement (excessive heat loss) and long waiting time (due to steel shop logistic) in integrated steel plants and thus torpedo ladle became so popular.

During refractory design development period, it was clear that torpedo lining requires better refractory than hot metal ladle (fired alumino-silicate bricks). During initiation years of torpedo ladles, a lining life of 200/300 heats was considered satisfactory. However, there was need to upgrade the service life to reduce the frequency of relining as this is completely unproductive time for the steel shop. With time, chemically bonded alumina-silicon carbide-carbon (ASC) brick became the suitable working lining refractory in torpedo ladle and fired alumino-silicate has taken place of back-up lining in torpedo lining. And the steel shops have achieved improved torpedo refractory lining life +500 heats life (like +100,000 mt hot metal throughput) in early 2000s or so. Way forward, improved quality of ASC brick was developed and lined in torpedo ladles and increased service life of 800 heats or so. But extending +1000 heats with just superior quality initial ASC brick lining was not easy. Refractory researchers then came up with monolithic repair mass and lining technique which helped to extend the torpedo service life to a level of 1500+ heats.

The monolithic repair mass for torpedo ladle was of different types, based on facilities and experiences of refractory manufacturers and steel shop. There are varieties on material type as well as lining technique such as low cement or medium cement castable and cold/ hot gunning and shotcrete techniques. Based on primarily steel shops facilities and logistic scopes and refractory manufacturers experiences, the strategies for implementation of working lining refractory maintenance plan and adoption techniques are considered to increase the service life of torpedo lining finally.

Generally, in torpedo ladle maintenance, first the bottleneck areas for performance achievement/ enhancement are analyzed. These areas are generally the impact area and the spout area, whereas occasionally the trunnion area and the barrel area, based on specific steel plant torpedo ladle design and wear-out pattern. The repair monolithic performance plays a very significant role, starting from mid-campaign period to end of torpedo ladle life. The development of spout area castable is targeted to have high resistance to corrosion by hot metal & slag, good resistance to abrasion during pouring of liquid metal at elevated temperature & minimize the differential erosion between castable & ASC bricks at junction area. Whereas the development of impact area castable is targeted to have high resistance to mechanical impact, abrasion resistance from hot metal & slag during pouring of liquid metal at elevated temperature. Obviously the spout area and impact area are the most critical zones of torpedo ladle that guide final performance and hence specific consumption of refractory is mostly dependent on the performance of castable used in spout and impact areas. This case study describes the improvement process of such shotcrete castable for torpedo ladle application.

CASE STUDY

Castable technology is quite old but a complex one with continually upgrading material concepts. The choices of aggregate, matrix and binder, and additives depend on the application requirements of that castable. The torpedo ladle applicationdemand that shotcrete castable should have good properties in volume stability, abrasion resistance, thermal shock resistance and strength, whereas rheological features wise good flowability is must, in addition to quick setting time and lower rebound loss. Here in this case, sintered mullite and silicon carbide are used as aggregates and the technical understanding was not to modify these but apply changes in matrix to bring improvements in properties and performance of torpedo shotcrete castable. Originally matrix concept of medium cement castable with Tabular alumina in fines was not changed but modification was brought in type of cement and calcined alumina concepts. Usage of 70% alumina cementgrade S70 was changed to 80% alumina cement of grade CA 25R and calcined alumina grade M4 was changed to bi-modal reactive alumina grade CL 370. The mix concepts for improvementtrials is mentioned in the table-1. The original/ base recipe is mentioned as “B” and changes are mentioned with “C” and “D”. The table-2 mentions the physical-chemical properties of components which brought key changes in castable properties and parameters.

Tab.1: Formulation concepts of MCC type shotcrete mass

Type	Materials\ Recipe	B	C	D
Aggregate	Sinter Mullite	XX	XX	XX
	SiC	XX	XX	XX
Matrix & Binder	Tabular Alumina	X	X	X
	Calcined Alumina M4	X	X	-
	Reactive Alumina CL 370	-	-	X
	CAC70%, S70	X	-	-
	CAC80%,CA25R	-	X	X
Additive	Silica Fume+Additives	x	x	x

Tab.2: Key features of matrix components

	S70	CA25R	M4	CL370
Al_2O_3, %	70	81	99.6	99.7
CaO, %	29	18	0.03	0.03
Na_2O, %	0.2	0.2	0.35	0.10
Fe_2O_3, %	0.1	0.1	0.03	0.03
SiO_2, %	0.2	0.2	0.03	0.03
BET, m2/g	0.42	0.55	6.0	3.0
-45µm, %	78	83	99.1	99.8
D50, µm	12	9	3.5	2.5
D90, µm	65	55	20	7

The above recipes were mixed at water demand of 7-8% and checked for rheological properties in lab conditions. Standard bars of the tried castables were casted and checked for density, porosity, compressive and flexural strengths, permanent linear change after prefiringat different firing temperatures up to 1400ºC. Bars prefired at 1400ºC/ 5 hrswere tested for hot modulus of rupture (HMOR) at 1400°C with 30 minutes soaking time. Bars prefired at 1400ºC/ 5 hrs were tested abrasion resistance test as per ASTM C704. Initial and final setting time of castables are mentioned in table.3 along with water demand and wet-out time.The other results of the conducted tests are mentioned in figures 1-7 below.

Tab.3: Casting rheology in standard castables

Parameters	B	C	D
Water demand, %	8.0	8.0	7.0
Wet-out time, sec	70	68	58
Initial setting time, mint	195	135	115
Final setting time, mint	250	170	155

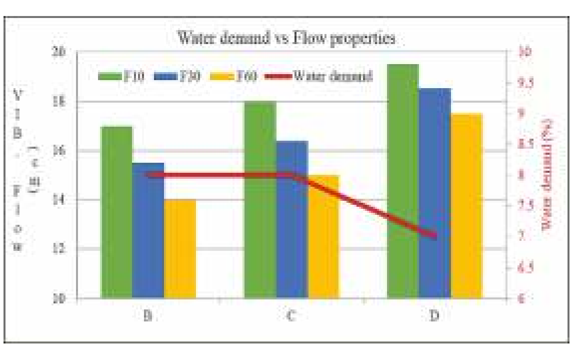

Fig.1. Water demand and flowability

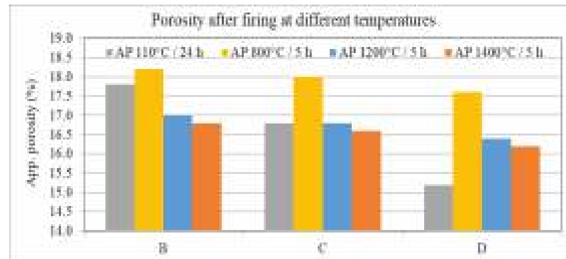

Fig.2. Apparent porosity of prefired castable bars

The change from 70% CAC to 80% CAC caused drastic reduction in setting time in set-C and set-D whereas presence of microfines aluminas from bi-modal reactive alumina CL 370 facilitates better hydration reaction in set-D. Castable water demand also was less in set-3 due to better packing. The flowability was also better in set-D due to better packing with bi-modal reactive alumina.

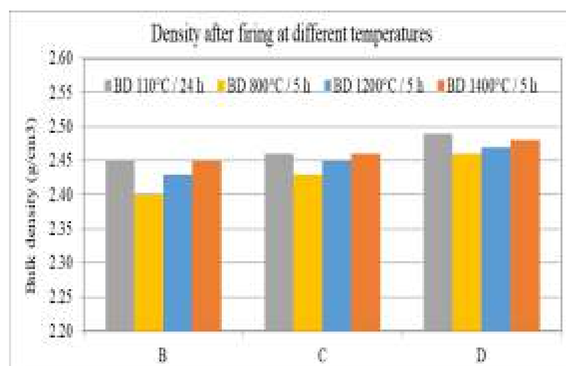

Fig.3. Bulk density of prefired castable bars

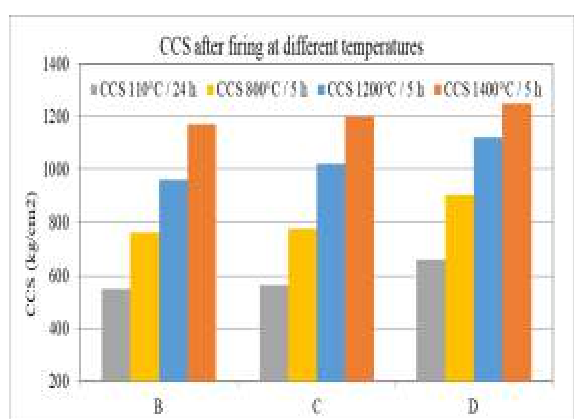

Fig.4. Compressive strengths of prefired castable bars

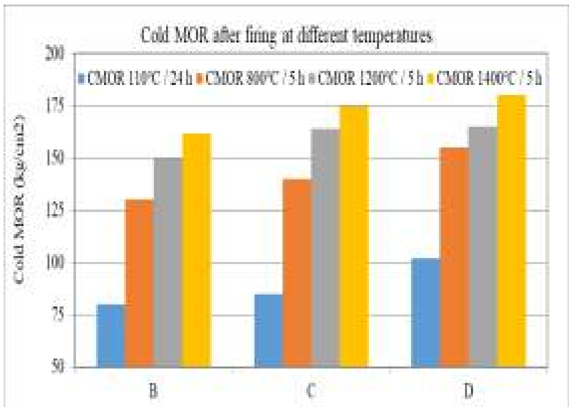

Fig.5. Tensile strengths of prefired castable bars

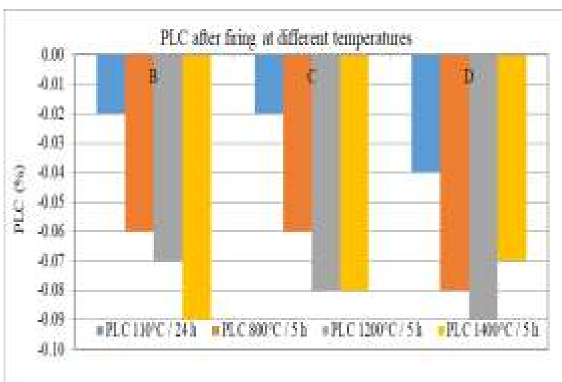

Fig.6. Permanent liner change of prefired castable bars

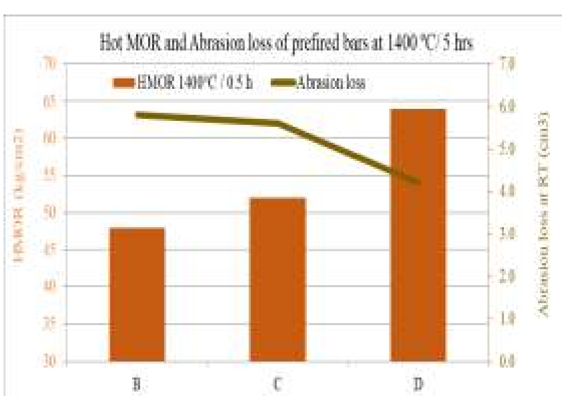

Fig.7. HMOR, abrasion resistance of prefired castable bars

Bi-modal reactive alumina CL 370 enhanced particle packing. This altogether worked for reduction in porosity and improvement in density and strengths parameters in final set-D.The better sinter reactivity of reactive alumina, in presence of silica fume helped for secondary mullite formation and further strength development in set-D. Volume stability can be linked to PLC and was under control. Hot MOR was found to be maximum in set-D whereas abrasion loss was minimum among all sets in set-D.

INDUSTRIAL APPLICATION BENEFITS

The improved shotcrete mass of set-D was applied in application along with special additive which accelerates to set the castable quicker after pumping to the working lining. In actual field application, the water demand was 6% and having only 5% rebound loss. Each shotcrete repair used to build up 2-3 inch castable thickness over eroded ASC working brick lining. After each cold repair, 24 hrs curing was maintained and then put in preheating before taking the ladles into circulation. The usage of such improvement shotcrete mass are tabulated in table.2 below with plant and torpedo capacities and overall torpedo life and shotcrete mass consumption. Normally 1st shotcrete repair starts after 450-500 heats life and continues repeated cold repairs with shotcrete mass at a gap of 250-300 heats. Thus totally 4-5 times cold repair are done in full torpedo life. It was observed that there is average 200 heats improvement in overall torpedo life and shotcrete castable consumption has significantly reduced by 5-10 mt in quantity which clearly signifies better performance of the improved shotcrete castable.

Tab.3: Successful application details

	Plant-1	Plant-2
Plant capacity	12 mtpa	10 mtpa
Torpedo capacity	350 mt 380mt	200 mt 380 mt
Earlier torpedo life	1500-1600 heats	
Improved torpedo life	1600-1800 heats	
Earlier shotcrete consumption	50-60 mt, 12-15 mt per repair	
Improved shotcrete consumption	45-50 mt, 10-12 mt per repair	

CONCLUSIONS

- Selection of proper 80% high alumina cement is essential for achieving proper rheology as well as desired setting behaviour. CA25R cement plays vital role here having quicker setting time to 70% purity alumina cement used before.
- Castable water demand control is very essential to reduce porosity and provide stronger matrix to achieve volume stability with sufficient strengths after firing. Bi-modal reactive alumina CL 370 plays essential role here.
- Right choice of right matrix with bi-modal reactive alumina CL 370 developed secondary mullite formation in presence of silica fume and provide best hot tensile strength and lowest abrasion loss.
- With developed improved shotcrete mass, castable consumption reduced significantly and overall life of torpedo ladle increased.

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- Ricardo Couto, Braulo Hemétrio, Roselaine Magalhães, Marco Antônio Quintela Usiminas S.A; Development of Refractories for Torpedo Ladles; UNITECR 2019; p. 353-364

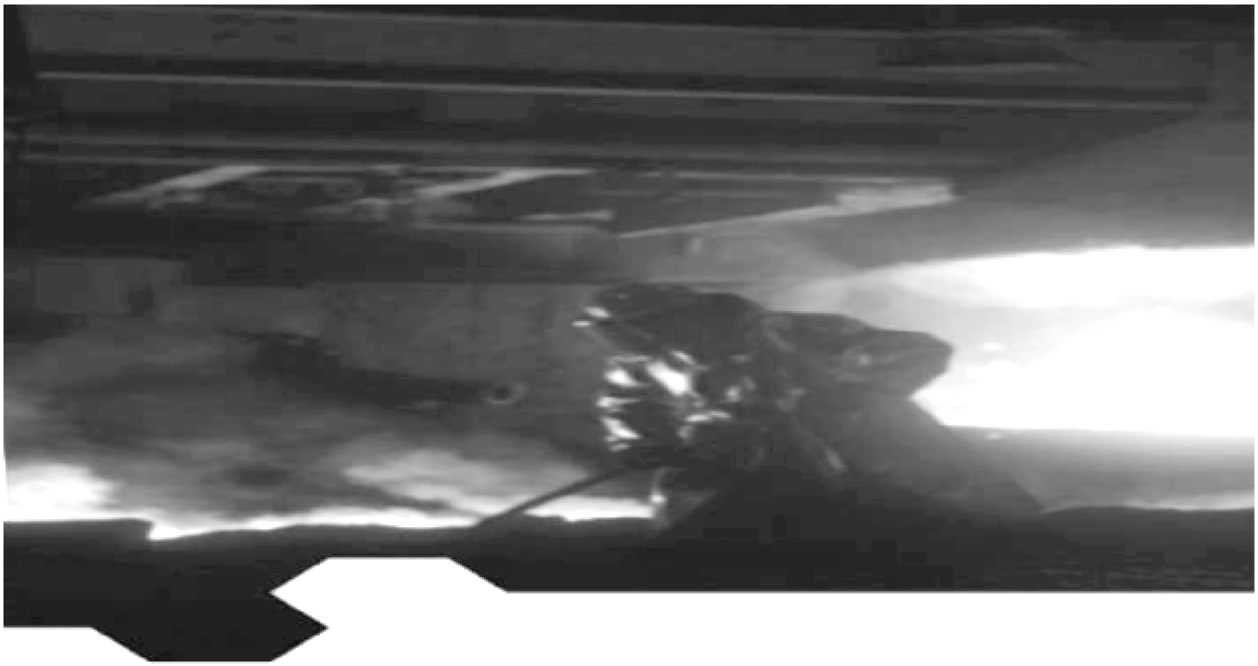
STATISTICS

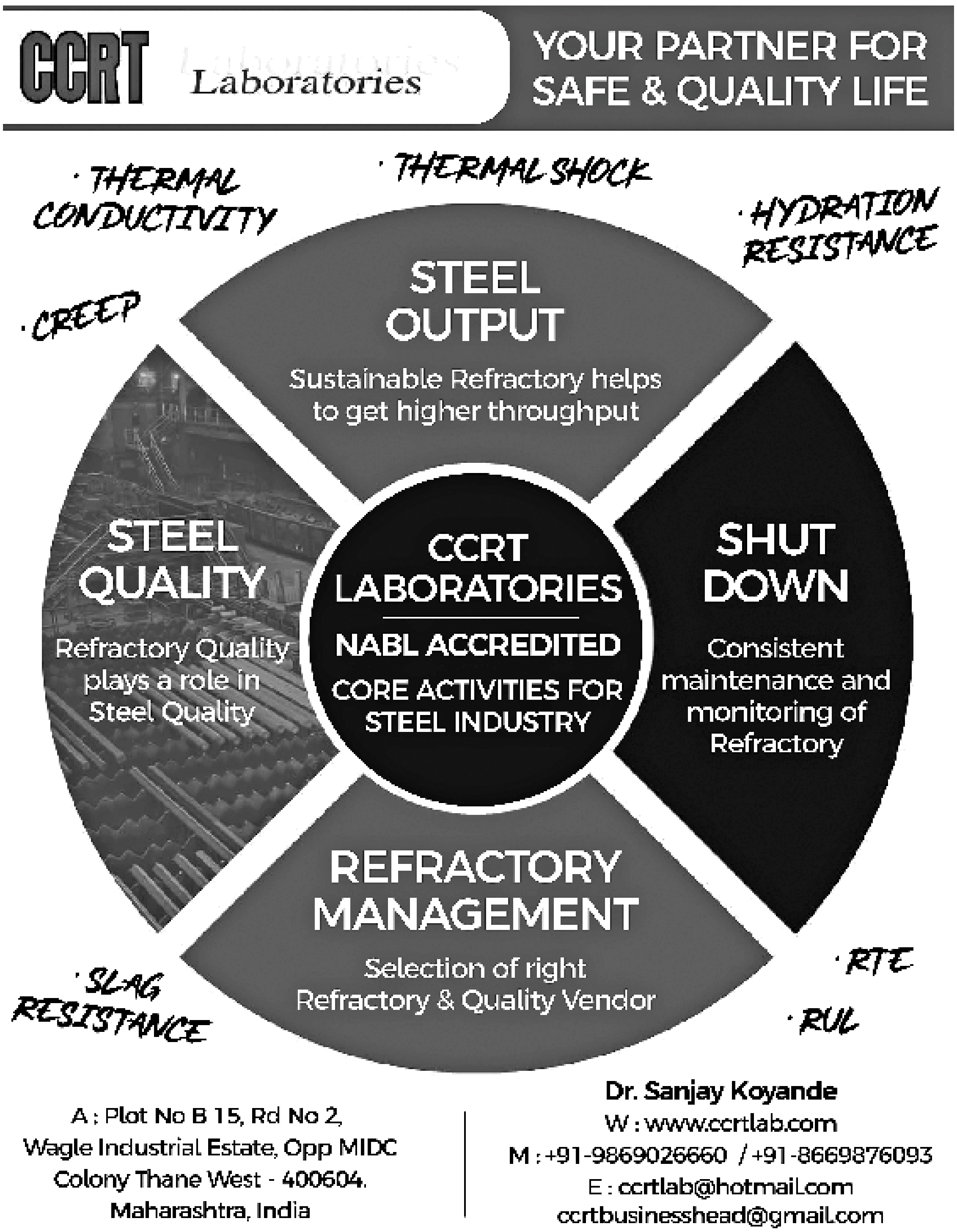
EXPORT & IMPORT OF REFRACTORY ITEMS

EXPORT OF REFRACTORY ITEMS	2023-24 Rs. Lakhs
FIRE CLAY BRICKS & SHAPES	17670.14
HIGH ALUMINA BRICKS & SHAPES	142344.36
SILICA BRICKS & SHAPES	2417.37
BASIC BRICKS & SHAPES	21869.71
MONOLITHICS/CASTABLES	59762.90
SPECIAL PRODUCTS	45991.79
CERAMIC FIBRES ETC	21862.44
OTHERS	21960.00
TOTAL	333878.71

IMPORT OF REFRACTORY ITEMS	2023-24 Rs. Lakhs
FIRE CLAY BRICKS & SHAPES	2243.63
HIGH ALUMINA BRICKS & SHAPES	121984.03
SILICA BRICKS & SHAPES	74668.05
BASIC BRICKS & SHAPES	180728.24
MONOLITHICS/CASTABLES	129930.33
SPECIAL PRODUCTS	3576.06
CERAAMIC FIBRES & OTHERS	40630.13
OTHERS	40574.09
TOTAL	594334.56

(Source: Export Import Data Bank, Department of Commerce, Ministry of Commerce & Industry, Govt. of India)

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REFRACTORY MANAGEMENT
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· SLAG RESISTANCE
· RTE
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A : Plot No B 15, Rd No 2,
Wagle Industrial Estate, Opp MIDC
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CCRT means Refractory
Steel & Metal Industry
Refractory means CCRT
Cement Industry
Glass Industry
CCRT Laboratories
NABL Accredited Refractory Testing Facility
Boiler & Other
Petrochemical
Fertilizer & Chemicals
Third Party Test and Witness Services
Refractory Failure Analysis
Testing of Refractories
API 936 Inspector Services | Third Party Inspections | Refractory Product Development
Assistance in RefractoryUnit Setup/Turnkey Consultancy
CCRT Laboratories
Thane - Head Office
Surat - Branch Office

SHREE SADASHIV REFRACTORIES PVT LTD

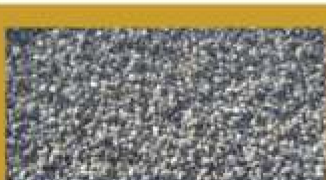
ABOUT US

Shree Sadashiv Refractories Pvt Ltd is an emerging company in the business of Mining and Processing of Refractory Raw Materials in Jamnagar, Gujarat in India. We are engaged in producing Refractory Raw Materials like Calcined Bauxite, Calcined Clay & Chamotte.

MISSION

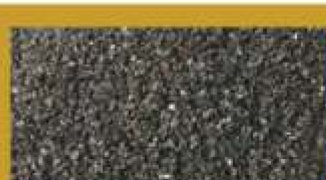
SSRPL's core business mission hinges on its' commitment quality and service and offering raw material products consistent in size, chemistry & physicality. Our Laboratory is equiped with latest equipment for testing as per the industry standard.

KEY PRODUCTS



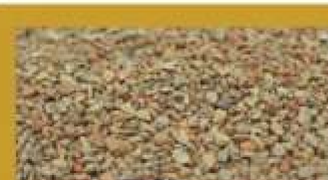
CALCINED BAUXITE

Refractory Bauxite, also known as Calcined Bauxite is produced by sintering high alumina bauxite in rotary kilns at high temperatures.



BROWN FUSED ALUMINA

Calcined Bauxite is heated to Temperatures above 2000°C through smelting process in Arc Furnaces. Then slow solidification process is followed to get blocky crystals, which in other words is known as Brown Fused Alumina.

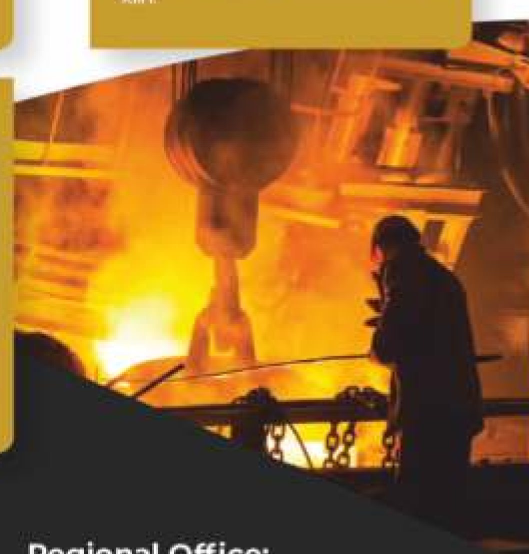


CALCINED CLAY

Calcined clay is obtained by calcining (heating) superior grade clay at high temperature in Rotary Kiln.

WHITE FUSED ALUMINA

White Fused Alumina is manufactured by the Fusion of Pure Quality Calcined Alumina in Arc Furnaces with Temperatures greater than 2000°C. After Slow solidification, a high purity synthetic material is obtained.



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Printed and published by Mr. Anirbandip Dasgupta, on behalf of Indian Refractory Makers Association and printed at **Q**uality **S**upply **S**yndicate, 219C, Old China Bazar Street, 2nd Floor, Room No. C - 10, Kolkata - 700 001 and published at, IRMA, 41, Shakespeare Sarani, Kolkata - 700017, Editor : **Dr. I. N. Chakraborty** ◆ **R.N.I. Regd. Number 34845/79**