ISSN 0250- 5304

IRMA JOURNAL

(for Private Circulation Only)

Volume LVII, No. 2, June 2024

Quarterly Journal Of Indian Refractory Makers Association





IRMA
PARTNERING HEATING SOLUTIONS
INDIAN REFRACTORY MAKERS ASSOCIATION

Address : Indian Refractory Makers Association, Duckback House, Flat No. - 2B, 2nd Floor, 41, Shakespeare Sarani, Kolkata 700017
Contact : 0914003-2748
Email : support@irmaindia.org
Web : www.irmaindia.org

Noble Refractories

Excellence in Quality Refractories

[NOBLE] SINCE 1982

PRODUCT RANGE

- Low Iron Special Refractories (Zircon, Zirmul, Mullite, Sillimanite etc.)
- All types of Super Duty & High Alumina Refractories
- Alumina Silicon Carbide Carbon Bricks
- Hi-Tech Insulation Bricks upto 95% Alumina
- Low Cement, Ultra-Low Cement & No-Cement Castables upto 95% Alumina
- High Alumina & High Purity Dense Castables (Conventional)
- Self Flow Dense Castables (Conventional)
- Medium Purity Dense Castables (Conventional)
- Medium & High Purity Insulating Castables.
- All Types of Fireclay, High Alumina & Special Mortars
- PCPF upto 95% Alumina.
- Hi-Tech Products (Monolithics) for Critical Applications area
- Basic Rammig Mass, Gunning Mass & Mortars
- Silica Ramming Mass & Mortars
- Plastic Refractories
- Cordierite Kiln Furniture's

Recipient of National Awards for Best Entrepreneurship, R & D, Innovation, Quality Products & Lean Manufacturing Techniques.

National Award

National Award

INDUSTRIES WE SERVE

Cement

Ceramic

Chemical

Glass

Iron & Steel

Foundry

Non Ferrous

Power Generation

Sponge Iron

Noble Refractories (An ISO 9001 & ISO 14001 Company)

+91 97121 05859 | +91 99789 22800

info@noblerefractories.com website: www.noblerefractories.com

27, National Highway, PO Box No.202, Hasanpar, Wankaner (Dist.: Morbi) 363621, Gujarat, India.

MADE IN INDIA

D&B Decide with Confidence

Vol. LVII, No. 2, June 2024

IRMA JOURNAL - A Publication of:
INDIAN REFRACTORY MAKERS ASSOCIATION
41, Shakespeare Sarani, Duckback House,
Unit-2B, 2nd Floor, Kolkata 700017
Phone: 033 4003-2748
Mobile: 98304 24582
E-mail: secretary@irmaindia.org
Website: www.irmaindia.org

CONTENTS

MESSAGE FROM THE CHAIRMAN

Dear Colleagues,

With a sustained momentum of investment across different sectors, overall steel demand in India is projected to grow at a CAGR of 5 per cent to 7.3 per cent over the next decade leading to a steel demand of 221-275 million tonnes by FY 34 (under different scenarios), according to a report by Deloitte.

Government of India continues to spend substantial amount on development of infrastructure like highways, industrial clusters, dedicated freight corridors etc. This is amply reflected in the recently tabled budget by Hon'ble Finance Minister Smt. Nirmala Sitharaman. Among projects outlined in the budget include a massive investment of Rs 10 lakh crore in urban housing, a rural roads programme worth Rs 26,000 crores. The capex budget for FY2025 has been pegged at Rs 11.1 lakh crores or 3.4% of GDP. More cities will get Namo Bharat and Metro Rail infrastructure projects while railways will receive a capital outlay of Rs.2.4 lakh crore, the highest allocation ever since 2013–14.

From FY14 to FY24, India's finished steel consumption posted a CAGR of 5.67 per cent. In FY24, domestic finished steel consumption reached 136 million tonnes, marking more than 14 per cent year-on-year growth driven by sustained momentum across developmental projects and increased government spending in various end-use industries.

While these are very welcome news for our growth, some of the recent issues being faced by our industry are sudden spurt in the prices of synthetic alumina especially WFA as well as wide swing in container freight tariff (which is on a steep upswing since April 2024). Fact of the matter is India does not have good quality natural raw materials, both bauxite and magnesite. In the past number of attempts were made for beneficiation/value addition of indigenous raw materials but commercially successful ventures could not be set up due to a host of factors. It is high time we re-intensify our efforts in that direction while speeding up the production of synthetic raw materials in our country.

.

Ish Mohan Garg
Chairman

ASSOCIATION ACTIVITIES

IREFCON 24

IREFCON 2024 will be organized from 13th-15th November 2024 at Taj Cidade de Goa, Horizon, Goa. Delegate registration has already started.

Keynote Speeches

Dr. Atul Vaidya, National Environmental Engineering Research Institute (NEERI)

Dr. Atanu Ranjan Pal, Tata Steel Ltd

Dr. Anjan Kumar Chatterjee, Conmat Technologies

Dr. Helge Jansen. Managing Director Refratechnik Steel GmbH

Theme Lectures

Mr. Azim Syed, RHI Magnesita

Mr. Danilo Bomfim, Shinagawa Brazil

Mr. Marcel Peekel & Mrs. Ana Gouveia Gil, Tata Steel Netherlands

Ms Kopal Agrawal, Hindalco Industries Ltd.

Mr. Mike O'Driscoll, IMFORMED Industrial Mineral Forums & Research Ltd

IREFCON24 Organizing Committee meeting was held under the chairmanship of Mr. Sunanda Sengupta on 3rd February 2024 on online platform. Issues discussed were flow of events for IREFCON'24, tentative budget, CEO meet, participation of customers, sponsorship, exhibition and registration charges.

IREFCON'24 Technical Committee meeting were held under the chairmanship of Dr. Arup Samanta on 18th April, 21st May & 21st June 2024. Issues discussed were finalization of speakers for Keynote Speeches and Theme Lectures, review of abstracts submitted for case studies and oral presentations, duration of presentations etc.

Room booking at IREFCON'24 venue is now open. Members may reserve the rooms available at a discounted rate directly from IREFCON website.

Further details are available at www.irefcon.com.

IN THE NEWS

SAIL

As per Steel Authority of India Ltd CMD Amarendu Prakash, the company will be investing Rs 6,500 crore towards capex during the current financial year as part of its Rs 1 lakh crore investment plan over the next few years. In the first phase from (the capacity) 20 million tonnes, SAIL will go to 35 million tons tonnes per annum by 2031. In the next phase, it make it 50 million tonnes.

JSW Steel

JSW Steel will spend a little over ₹19,000 crore on capacity addition, which will help it cater to the demand for value-added special steel products. The cost of JSW Steel's third phase of capacity expansion at its plant in Dolvi will be among the lowest for brownfield expansions for the company.

Indian cement industry

Indian cement industry has witnessed a

muted growth of 2-3 per cent in the first quarter of current fiscal on account of a slowdown in construction activity because of the Lok Sabha polls, according to a report from rating agency Icra. However, the overall volumes for the FY2024-25 are likely to expand by 7-8 per cent driven by a healthy demand from the infrastructure and housing sectors.

Shyam Metalics

Shyam Metalics and Energy Ltd will invest Rs 650-750 crore in its stainless steel business over the next few years. The company will establish a state-of-the-art stainless steel hot rolled coils (HRC) facility at its existing plant in Sambalpur, Odisha. This facility, with a capacity of 0.3 million tonnes per year, will specialise in producing high-quality 200 and 400 series stainless steel hot rolled coils.

Coal India

Coal India Limited (CIL) has taken steps to ease e-auction norms like lowering the earnest money and enhancing the quantity of the dry fuel on offer. The company is also planning to tweak its auction and allocation methodology, as it aims to encourage increased participation. CIL has further asked all its arms barring Northern Coalfields Ltd, to spike up their offer quantity under e-auction to 40 per cent of their respective total production for the second and third quarters of this financial year.

Vedanta Ltd

Vedanta Ltd has reported a rise in production of aluminium, zinc, iron ore and steel in the June quarter. The aluminium output grew 3 per cent to 5,96,000 tonnes in the first quarter over the year-ago period. At Zinc India, the saleable metal output grew to 2,62,000 tonnes over 2,60,000 tones. The production of saleable iron ore rose to 1.3 million tonnes over 1.2 million tonnes in the year-ago period.

OVERSEAS NEWS

Bosai Minerals

Bosai Minerals Group Guyana Inc. is expanding the Metallurgical Bauxite Project (MAZ). This initiative of the company is set to increase bauxite production from 1 million tonnes annually to 3 million tonnes per annum.

RHI Magnesita

For the year 2023, RHI Magnesita's revenue was €3,572 million, increased by 8% mainly driven by contribution from acquisitions, offsetting a demand driven 5% decline in sales volumes in the base business. The company delivered a 7% increase in Adjusted EBITA to €409 million (2022: €384 million), as M&A, cost saving initiatives and resilient pricing offset the underlying weakness in customer demand. Adjusted operating cash flow increased by 166% to €413 million.

Krosaki Harima Corporation

Krosaki Harima has received an order from a Japanese electric arc furnace steelmaker to deliver a robot which automatically replaces fire bricks of steelmaking facilities. The robot was developed in-house by Krosaki Harima, and this is the first time that the company received an order for the robot. The robot is scheduled to begin operations from fiscal year 2025. It is designed to replace the refractory called 'SN Plate' attached to the bottom of molten steel ladles. Normally the replacement work is carried out by people, but using Krosaki Harima's robot called 'REX-ROBO' will enable all the work related to replacement to be fully automated. The robot will improve the safety of the work since there will no longer be a need for staff to conduct the work while being subjected to high temperatures.

Shinagawa Refractories

Shinagawa Refractories will establish a new manufacturing plant of alumina graphite flow control refractories for continuous casting of

steelmaking in Liaoning, China. Shinagawa and Anshan Hefeng Refractory Material, established Liaoning Shinagawa Hefeng Metallurgical Material ("Shinagawa Hefeng") in 2008 as a joint venture to locally produce mold powder for continuous casting. In 2024, the year that marks the 16th anniversary of this successful joint venture, Shinagawa and Hefeng decided to seek further growth through Shinagawa Hefeng and to build a new flow control refractory production facility within Shinagawa Hefeng's premises.

Calderys

Calderys has supplied equipment, refractories and expertise to steel plant manufacturer, Sarralle, to put into operation the world's first ladle preheating station running on 100% green hydrogen as fuel. This groundbreaking innovation, undertaken by Sarralle for Arcelor Mittal Sestao, Spain, allows a significant reduction in CO2 emissions and, it is hoped, will also reduce operating costs in the long term, compared to using natural gas as a fuel. For this project, Calderys manufactured and installed the burner precast component, and also supplied and installed the castables to line the preheater.

Bauxite production of Guinea

Guinea's bauxite production and exports increased for the third consecutive year in 2023. The West African nation is one of the world's biggest producers of bauxite, having 40 billion tonnes of mining capacity in Boké, Fria, Gaoual, Télimélé, Pita-Labé, Mali, Kindia, Dabola, Tougué, Lelouma, Mamou, Dalaba, Koubia. In 2023, Guinea produced about 123 million tonnes of bauxite, up over 19 per cent year-on-year.

MEMBERSCAN

IFGL Refractories Ltd

IFGL Refractories has reported a revenue of ₹16.4b in FY 2024 (up 18% from FY 2023), the net income was ₹816.7m (up 3.1% from FY 2023), while the profit margin was 5.0% (down from 5.7% in FY 2023). The decrease in margin was driven by higher expenses.

Maithan Group

The Alumina Industrial Company, established by the Maithan Group and Bathwal Corporation, intends to develop UAE's first complex to make speciality products from alumina in Khalifa Economic Zone Abu Dhabi. Emirates Global Aluminium, the largest industrial company in the United Arab Emirates outside oil and gas, has signed an agreement to supply alumina to The Alumina Industrial Company, enabling the development of a new industry making speciality products from alumina. The Alumina Industrial Company plans to develop a plant in KEZAD with a production capacity of 80 thousand tonnes per year of specialised alumina products, with the potential to expand to 150,000 tonnes annually.

RHI Magnesita India Ltd

RHI Magnesita India will supply a technology package for JSW Vijayanagar Metallics' new SMS#4 expansion project. This includes the latest generation SX3 slide gate, EMLI LadleSlag sensors as well as robotic cells on the CCM for ladle shroud handling and tundish sampling and probing as part of a long-term contract. RHI Magnesita India has introduced, for the first time in India, innovative digitalization and automation projects for ladle lining in the customer's SMS#4 - a Scissor Table for Ladle Lining and the VISIR LadleSafe for Ladle Monitoring System.

The company expects exports to contribute close to 25% in 2025 and 30% in 2027-2028, from 12% now. It also anticipates market share in India to rise to 40%.

Refratechnik India

Refratechnik Visakhapatnam Plant has recently informed that the Umbrella Certification Audit for ISO 9001:2015 "Quality Management System" has been successfully completed without any issues and has been recommended for certification.

TRL Krosaki Refractories Ltd

Mr. Prasanta Kumar Naik has been appointed as the Managing Director of TRL Krosaki Refractories Ltd with effect from May 1, 2024. He succeeds Mr. Priyabrata Panda, who superannuated after serving the Company for around 10 years as its Managing Director. Mr. Naik has a rich experience of around 33 years in refractories industry working in leadership positions across different functions, such as, Production, Associate Operation, Procurement, Strategic Sourcing, Mines, Energy Management, Marketing & Sales etc.

Vesuvius India Ltd

Mr. Mohinder Rajput has recently joined Vesuvius India Ltd as its Managing Director. He replaces Mr. Nitin Jain who will take up a new role of Dy. President, Advanced Refractories at Vesuvius Global.

ECONOMY AT A GLANCE

- As per IMF, India is expected to grow 7% in 2024, higher than April's projection of 6.8%. This can be largely attributed to improvements in private consumption, especially in rural parts of the country. That's a big drop from 8.2% growth in the fiscal year from April 2023 to March 2024. Growth will continue to decline and reach 6.5% in 2025, the financial agency said.
- China's economy is predicted to grow 5% this year, unchanged from IMF's May prediction. This is higher than its April projection of 4.6% but lower than the 5.2% expansion in 2023.
- Global growth in 2024 is expected to grow at 3.2% — unchanged from its April forecast, and will likely increase slightly to 3.3% in 2025.
- The U.S. economy is predicted to inch higher to 2.6% this year compared to 2023, slightly lower than its 2.7% projection in April.
- Growth in the euro zone for this year has been upgraded to 0.9% — 0.1 percentage point higher than April's projections, driven by stronger momentum of services and more-than-expected net exports in the first half of 2024.
- According to the RBI's monthly bulletin, the second quarter (July-September) of 2024-25 has begun with signs of quickening momentum in the Indian economy as an improvement in the outlook for agriculture and the revival of rural spending have turned out to be the bright spots in the evolution of demand conditions.
- India's forex reserves has hit an all-time high of $657.16 billion, as per data available till July 5. Gold reserves expanded by $904 million to $57.43 billion.

BUSINESS SECTION:

DECARBONIZATION OF CEMENT INDUSTRY: EXCERPTS OF NITI AYOG DOCUMENT

INTRODUCTION:

The cement industry emits approximately 7% of global CO_2. The majority of these emissions come from the calcination of limestone for the production of clinker, the most prevalent component of Portland cement (which is itself the essential binding agent in concrete). Cement and concrete emissions can be reduced by:

— deploying concretes with better performance (i.e. less concrete needed in construction);

— using concrete with alternative compositions (i.e. less cement needed in concrete, ascement conte nt in concrete may already vary between 260 kg/m^3 and 400 kg/m^3 depending on the application [EN 206, 2021]);

— and reducing the clinker content of cement (i.e. less clinker needed in cement).

Further emissions come from the thermal processes necessary for the production of clinker, as well as electricity consumption for the production of clinker (grinding of raw materials and operation of kiln and ancillaries) and the production of cement (milling of clinker and additives).

While greenhouse gases can be accounted for in different ways (e.g. along ISO 14067, GCCA Cement CO_2 and Energy Protocol [GCCA, 2020] or the greenhouse gas protocol [GHG Protocol, 2022]), measures for accounting CO_2 emissions in the cement industry are as follows:

1. emissions including the CO_2 released by the calcination of calcium carbonate into calcium oxide (526 kgCO2/kg clinker [European Commission, 2013]) and the emissions from fuel combustion for the thermal processes for the production of clinker (which depends on the production process and type of fuel)
2. emissions including the CO_2 released for the production of electricity consumed in cement making (the electricity is mainly consumed in grinding raw materials, the clinker and additives and in minor measure operating the kiln and ancillaries).
3. emissions including the CO_2 released through the sourcing of raw materials and trade of intermediate products.

Challenges	
Decarbonization Roadmap for Cement Sector	
Scope 1	
Electrical Energy	◆ Improving efficiency through energy efficientequipment ◆ Renewable & Waste Heat ◆ Optimize Waste Heat Recovery System ◆ Waste Heat Recovery generation may be grantedthe status of Renewable Energy, which are operating with actual waste heat available ◆ Recovery power generation from chlorine bypasssystem ◆ Digitization and Industry 4.0

Reducing Carbon Footprint of Thermal Energy	◆ Improving heat efficiency through efficient pyrotechnology ◆ Innovation in Pyro-processing Technology ◆ Alternative green fuels (including green hydrogen)and Sustainable Biomass (Bamboo energy plant)to switch fossil fuels ◆ Artificial intelligence and Industry 4.0 in pyro-processing ◆ Heat Electrification from Renewable Power ◆ Solar Calcination/Clinkerisation ◆ New clinker systems
Enhancing use of Supplementary Cementitious Materials	◆ Enhancing the use of Blended Cements from the existing 73% to 100%, replacing Ordinary Portland Cement (OPC) with Portland Pozzolana Cement (PPC), Portland Slag Cement (PSC), Composite Cement (CC). ◆ Flyash based cements ◆ Enhancing the fly ash % in from the existing BIS limit of 35% to 40%. ◆ GGBF Slag Cements ◆ Limestone based cements ◆ Calcined clay/Natural Pozzolana based cements ◆ Multi-blend cements
Reducing Process Emissions	◆ Carbon Capture and Utilisation ◆ New Novel Cements with Low Carbon/No Carbon raw material
Reducing Emissions from On-site Vehicles and Equipment	◆ Electric, Plug-in Hybrid, Fuel Cells or Pure Battery

Challenges
Scope 2
Emissions reduction by use of Renewable Energy
Scope 3
Emissions reduction by : ◆ Concrete recarbonation during product use ◆ Use of electric vehicles in logistics operations ◆ Offsetting business travel ◆ Green procurements

Challenges
Scope 2
Emissions reduction by use of Renewable Energy
Scope 3
Emissions reduction by : • Concrete recarbonation during product use • Use of electric vehicles in logistics operations • Offsetting business travel • Green procurements

1. Policy Interventions

Sl. No.	Suggested Measures	Nodal Ministry/ Department	Timeline
1.	For Captive Wheeling, **Scheduling of power** should be allowed on monthly TOD basis and not in 15 minute time block basis	Ministry of Power	Short Term
2.	**Banking provision** should be provided for captive consumers wherein Yearly Banking of power should be allowed on RTC (round the clock) basis and shall be allowed even for Inter State transaction and Balance Power if any after the Financial Year shall be Procured by DISCOM on APPC Rate,	Ministry of Power	Short Term
3.	**No Capacity restriction, based on Grid contract Demand** on captive consumers, for Installation of Solar or other Renewable projects.	Ministry of Power/SEBs	Short Term
4.	**Grid Contract Demand reduction** on average basis equivalent to the RE capacity	Ministry of Power	Short Term
5.	**Evacuation Facilities** from RE Projectto Consumer premises should be provided by DISCOM for Intra State Consumers	Ministry of Power/SEBs	Short Term

6.	**Net Metering** should be allowed withno restriction on grid CD capacity	Ministry of Power/SEBs	Short Term
7.	Renewable energy Consumption should not be restricted to one State.In case of group units in different States, REC generated in one State should be allowed to comply RPO ofother States.	Ministry of Power/ Ministry of New andRenewable Energy (MNRE)	Short Term
8.	Facilitate availability of waste land for sustainablebiomass plantation/Carbonsink creation in wastelands of India	Ministry of Environment, Forestand Climate Change (MoEF&CC)	Short Term
9.	Introduce **landfill tax/polluter to pay** policy to promote circular economy models of greater waste utilization	MoEF&CC	Short Term
10.	Renewable power status for **Waste Heat Recovery** based power projects	MNRE	Short Term

2. Technological Interventions

Sl. No.	Suggested Measures	Nodal Ministry/ Department	Timeline
1.	Cross sector and cross country **collaborations** to tap advantages of each sector for policy advocacy,technical know-how and disruptiveincubations	Niti Aayog	Short Term
2.	Build cost competitive **Green Hydrogen** with vast RE resources	Ministry of New and Renewable Energy (MNRE)	Long Term
3.	Development of technology on **Solar Thermal Calcination**	MoP/DST/MNRE/ DPIIT	Long Term
4.	Development of technology on **Electrification** of Pyro-processing	DST/MoP/MNRE/ DPIIT	Long Term
5.	Development of Low Cost Technology on **Carbon Capture and Utilization**	DST/Department of Scientific and Industrial Research(DSIR)	Long Term
6.	Development of Technology for Utilization of **Green Hydrogen** inPyro-processing	MoP/MNRE	Long Term
7.	Knowledge Transfer for Transition to **Industry 4.0** for reduction in energy consumption	Niti Aayog/DPIIT/ DST/DSIR	Short Term

TECHNICAL SECTION

ENGINEERING OF PRODUCTS WITH REFRACTORY ARISING FROM STEEL MAKING FURNACES FOR COST BENEFITS AND SUSTAINABILITY

Asim Kr. Ganguly, Sr. Tech. Consultant (Reft.), &
Ajay Kr. Dasgupta, Former ED I/C, RDCIS, SAIL., Kolkata

Abstract

In India with the continued leveeling of bench marking performances for the Iron & Steel industries, the metallurgical furnaces have significantly improved the campaign lining life over the current years. But even then, approx. 20% of furnace lining remains as worn out refractories, which may be gainfully re-utilized. Cost components of refractories, are comprising direct refractory maintenance of steelmaking furnaces (RED), operational refractories (FCP) and related project activities for tonnage carbon steel plants is ranging from 3-4% of the end steel products, i.e. Rs. 2,500-2,800/-tfs approx., with the selling price of end steel products as Rs. 70,000/- per tonnne. A*t the end of the day, refractory manufacturers aim for continued reduction in the cost of making high duty refractories used for steelmaking, etc.*

Aiming to target customized advanced products, the reputed refractory manufacturers like, RHI Magnesita India Ltd., TRL-Krosaki Refractories Ltd., Vesuvius India Ltd., IFGL Refractories Ltd., etc. have their satellite production units in China, *due to proximity of sources of strategic critical raw materials at competitive prices. Cannibalization of* spent refractories *is therefore, absolutely essential in the overall thrust of raw materials economization and optimization of energy usage, besides demand for* environmental sustainability and equity. The paper highlights on engineering of developed products utilizing refractory arising from Steel Plant furnaces and refractory makers.

Introduction

The steel plant furnaces are consuming 75% (approx.) of the total refractories produced in any country. By now it is well known that furnace lining refractories, after campaign life remain as “residual refractories”, which may be potentially utilized by engineering suitable recycling techniques, either by the user steel industries or by refractory making plants.

Cost components of refractories, comprising direct refractory maintenance of steelmaking furnaces (RED), operational refractories (FCP) and related project activities for tonnage carbon steel plants is ranging from 3-4% of end steel products, i.e. Rs. 2,500-2,800/- per ton of finished steel(tfs) approx., taking the selling price of end steel products as Rs. 70,000/- per ton.

In view of the persistent constraints on easy availability of high duty raw materials and also for targeting customized advance products, the reputed refractory manufacturers like, RHI Magnesita India Ltd., TRL-Krosaki Refractories Ltd., Vesuvius India Ltd., IFGL Refractories Ltd., Calderys India Refractories Ltd., Quindao-Almatis Alumina Pvt. Ltd., Orind Special Refractories Pvt. Ltd., etc. have their satellite production units in China, due to proximity of sources of critical raw materials at competitive prices. It is, therefore, of much relevance that, used furnace refractories are gainfully utilized for raw materials economization, lower consumption of energy, improved housekeeping and for deriving environmental sustainability and equity.

Thrust for Recycling of used refractories from Steel processing furnaces

In the present day context, the main reasons for reuse of salvaged refractories from worn out linings of steel plant furnaces along with the thrust for related factors are explained in Table No.1 & Table No.2 below: -

Table No.1

Thrust factors for Reprocessing of Salvaged Refractories from Steel Processing Furnaces

Considerations for recycling of used/salvaged refractories	Weightage Factors		
	Very High	High	Moderate
Raw Material Savings	v	-	-
Reduced Energy Consumption	-	v	-
Plant Cleanliness	-	v	-
Environment & Equity	-	-	v

Table No.2

Intrinsic Benefits in Reusing of Worn out Refts. from Steel Processing Furnaces

Parameter(s)	Process Activities	Accrued Benefit(s)
Fresh Reft. Raw Materials	Reduced Consumption by Mass	Direct (Materials Saving)
Sintering of Raw Materials (Batch making)	Extent of Sintering is less for addition of used/fired Process Fce. Refts.	Direct (Energy Saving)
Final Firing of End Reft. Products	Reduced Firing Load in Reft. Making Fces.	(-Do-)
Product Quality (Reft.)	Better Control in Pyro-Physical properties	Quality Consistency
Shop Floor Up keeping	Lesser Handling of Waste (improved housekeeping)	Motivation of Work Force & reduction in environmental pollution
Environment (In & Out)	Stepwise Improvement	Sustainability & Equity (Long Term)

The residual refractories from furnaces are segregated in steel plant, either for reprocessing by the plants, (wherever, Granular Mass making facilities are available) or selling to the refractory manufacturers for their economic use in making of end products.

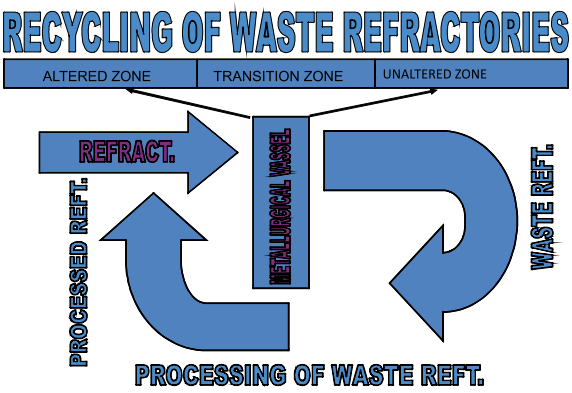
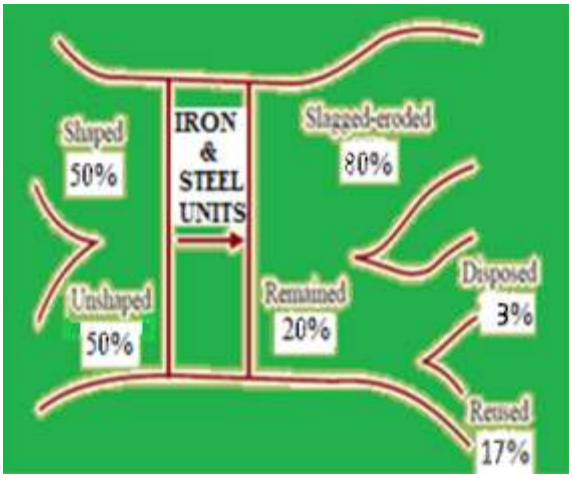


Fig. No. 1

The broad cycle of waste refractory utilization is shown in the Fig. No.1, while Fig. No.2, shows the materials balance of refractories in advanced steel plants. Out of the total refractories lining, ≈80% gets worn-out during operation of the metallurgical vessels, ≈20% remains as used refractories at furnace campaign end and from that 3-5% is discarded as waste material, while 17% (approx.) of used refractories are re-engineered as value added potential new materials.



Advances in Material Balance for Refts. in Steel Plants furnaces - Fig. No. 2

In fact, in the current scenario of scarcity of raw-materials and increasing energy cost, the recycling of used refractories are operative in "3R module" concept as depicted below to achieve a zero-emissions of operation (i.e. Reduce ,Reuse & Recycle) concept:-

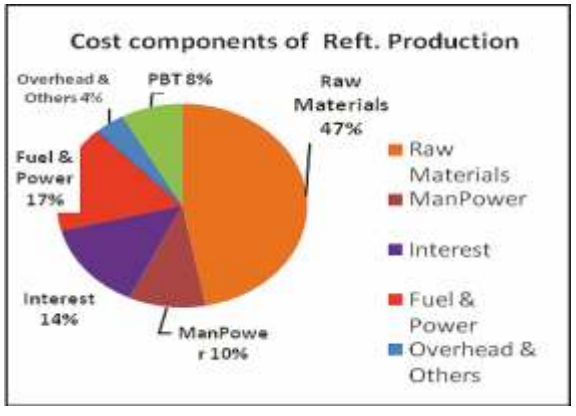
1) "Reduce" refers to activities that limit refractory use by relaxing operating conditions to minimize and reduce refractory deterioration and wear, and by improving refractory durability.

2) "Reuse" refers to the utilization of "Spent refractories" in production operations, as raw materials for refining molten steel and slag conditioners.

3) "Recycle" refers to the reuse of spent refractories as components of newer refractories making.

Cost Components of Refractory Products Making

If we break down the cost components of refractory production as depicted in Fig. No. 3 (Pie chart), it is evident that the raw materials of a product, comprise a major component in the finished products, which ranges from 46-47% approx. and that for energy component is 17% approx. This Pie- chart is related to a reputed refractory making plant, having products ranging from Coke Oven Silica, Alumino-silicate & High Alumina, Basic refractories (including MgO-C) & FCP and wide varieties of monolithics.

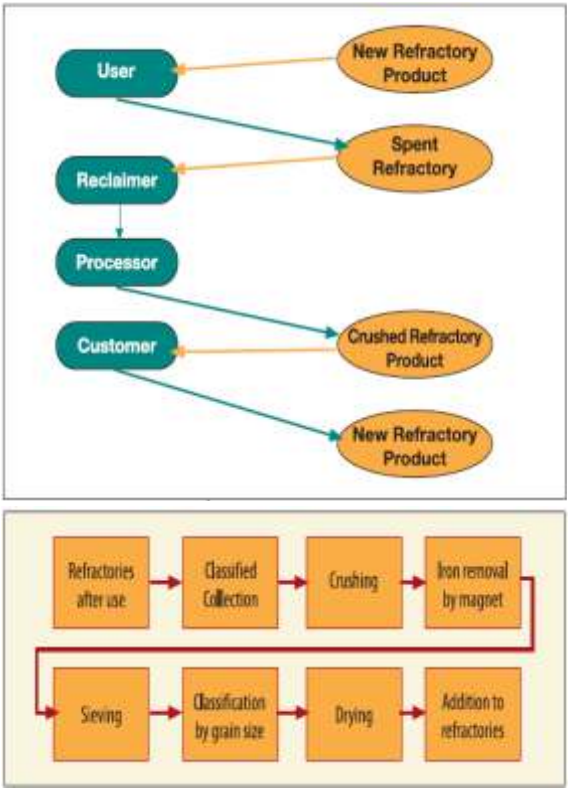


A-class Reft. Making Plant of India – Cost Structure - Fig. No. 3

Management of Waste Refractories – System

As indicated in the preceding section, the Fig. No.2, shows the ultimate materials balance of refractories in some of the advanced steel plants of India & abroad. From that it can be observed that out of the total refractories lining, 80% are getting worn-out during operation of the metallurgical vessels. Over the years of operation/maintenance improvements, refractories remaining after the service of lining is decreasing significantly.

It is important from an energy saving standpoint to improve the effective consumption rate, thereby reducing the percentage of residual refractories after service of the lining. Fig. No.4 shows diagram of recycling process and refractory recycling techniques, that are being practice in many of the advanced steel works.

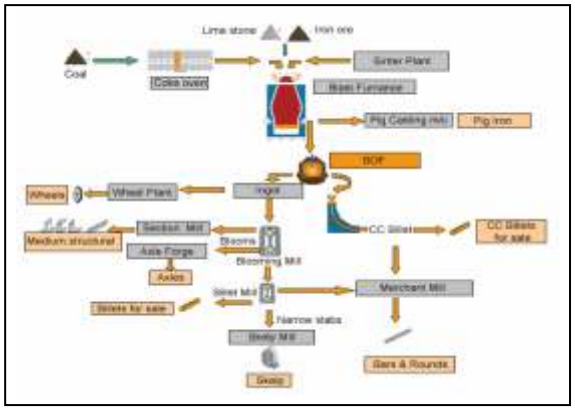


Techniques of Spent Refractories Recycling in a Modernised Steel Works (BOF-Concast Route)- Fig. No. 4

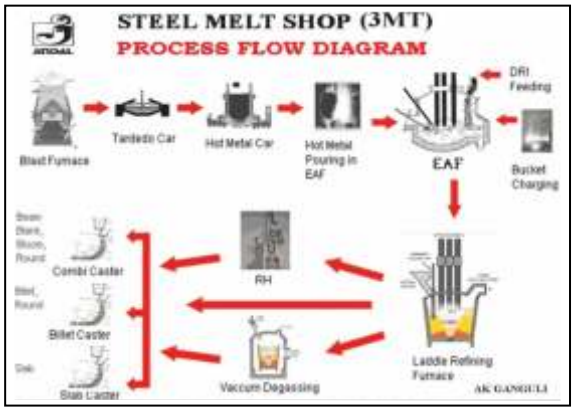
Steelmaking Process Lines & Refractory Consumption Trend

With domestic steel industries currently having advanced process technologies, refractory consumption per tonne of crude steel made is down to about 5-6 kg/tcs from the earlier higher level of 20-25 kg/tcs figured two decades ago.

Fig No. 4 & 5 depicts two typical flow charts of current steelmaking processes, using interlinked metallurgical process units (with BOF & EAF Routes) for the production of steel products.



Process Chart of DSP - SAIL, Durgapur using BF, BOF, SSM & CCM - Fig. No. 5



SMS Operation with EAF, SSM & CCM (JSPL, Raigarh) Fig. No. 6

In this context, Table No.3(a) to 3(d) pertaining to steel plants – DSP,BSL(SAIL), TSL(JSR), & JSPL(Raigarh) give the trend on the components of specific refractories consumption and cost in some leading steel plants of India producing long & flat steel products, having CO - BF - DRI/EAF, SSM and Concast process lines. In these categories of plants, high value basic refractories arising are available from BOF, EAF & Secondary Steel ladles after the campaign ends of metallurgical vessels.

Steel Plants processes and refractories manufacturing studies have revealed that It is always feasible to recycle 17-20% of spent refractories from the furnaces of the steel plants as well as during making of products in refractories manufacturing plants.

Table No. 3(a) -- Reft. Sp. Cons. (Kg/tcs) & Sp. Cost (Rs./tcs) during yrs. 2022-23 & 2023-24

Plant: DSP, SAIL (BOF – 130T, SSM Ladle – 130T

FY	Life of Met Units (heats)		Sp. Cons. (Kg/tcs)		Sp.Cons. (Kg/tcs)	Sp. Cost (Rs./tcs)
	BOF	SSM Ladle	BOF Shop	SSM Ladle	Plant (RED)	Plant (RED)
2022-23	4,907	71.5	0.82	6.8	9.6	732.3
2023-24	6,106	72.4	0.92	6.8	9.3	749.4

*Operational refts. (like, FCP) not included in Plant(RED).

Table No. 3(b) - Reft. Sp. Cons. (Kg/tcs) & Sp. Cost (Rs./tcs) during yrs. 2022-23 & 2023-24

Plant: BSL, SAIL (BOF –300T, SSM Ladle – 300T)

FY	Life of Met Units (heats)		Sp. Cons. (Kg/tcs)		Sp. Cons. (Kg/tcs)	Sp. Cost (Rs./tcs)
	BOF	SSM Ladle	BOF Shop	SSM Ladle	Plant (RED)	Plant (RED)
2022-23	5,193	97.5	0.75	3.32	7.17	549.6
2023-24	4,549	99.5	0.86	3.24	7.96	671.4

*Operational refts. (like, FCP) not included in Plant(RED).

Table No. 3(c) - Reft. Sp. Cons. (Kg/tcs) & Sp. Cost (Rs./tcs) during yrs. 2022-23 & 2023-24

Plant: Tata Steel, JSR (Shop: LD-2,(BOF – 165T,SSM Ladle -165T)

FY	Life of Met Units (heats)		Sp. Cons. (Kg/tcs)		Sp. Cons. (Kg/tcs)	Sp. Cost (Rs./tcs)
	BOF (165T)	SSM Ladle (165T)	BOF Shop	SSM Ladle	Plant (RED)	Plant (RED)
2022-23	7,500	161	0.97	2.1	6.9	Not Reported
2023-24	7,535	161	0.85	2.2	7.4	-do-

*Operational refts. (like, FCP) not included in Plant(RED).

Table No. 3(d) - Reft. Sp. Cons. (Kg/tcs) & Sp. Cost (Rs./tcs) during yrs. 2022-23 & 2023-24

Plant: JSPL, Raigarh (100T - EAF/NOEF, SSM Ladle – 100T)

FY	Life of Met Units (heats)		Sp. Cons. (Kg/tcs)		Sp. Cons. (Kg/tcs)	Sp. Cost (Rs./tcs)
	EAF/NOEF (100T)	SSM Ladle (100T)	EAF/NOEF (100T)	SSM Ladle (100T)	Plant (RED)	Plant (RED)
2022-23	697 – 1204	114	4.3	2.9	7.0	612.0
2023-24	777-1225	112	3.8	3.0	6.5	572.0

*Operational refts. (like, FCP) not included in Plant(RED)

Cannibalization of Refractory Arising from Metallurgical Process Units

The metallurgical processing units from which potential spent refractories are available for re processing / re-utilization, are also dependent to a large extent on the stabilized process parameters of the units, like BOF, secondary steel ladles, tundish assemblies, etc. where expensive magnesia-carbon, alumina-magnesia-carbon & alumina-carbon ranges of refractories are in use in different modules of vessels linings. In view of this it is of important to give an overview of the stabilized processed parameters for BOF & SSM ladles for different leading steel plants as indicated in the preceding section, vide Table no. 4(a) to 4(d).

Table No. 4(a) - Operating Regime of 130T–BOF & 130T- SSM Ladle

Plant: DSP (BOF, CCD), Yr.: 2023-24

Parameter	Data
BOF Cap.	130 T
BOF Tap Temp.(°C)	1660 - 1700°C
BOF Tap to Tap Time	63 minutes
Slag splashing of Heats(BOF)	70%
SSM Ladle Cap.	130T
On Line Purging (Ar)	100% of heats
SSM Route	LF – RH
Heats through LF/RH	100%
Metal Holding Time in Ladle	150 minutes
Casting Time (minutes)	82
Ladles in Circulation / Day	12 – 13 nos.
Heats/Day / Ladle (Nos.)	4 - 5
Slag Basicity	1.8
Steel Killing	Si- Killed
Ladle Life (Heats)	72.4

Table No. 4(b) - Operating Regime of 300T-BOF & 300T- SSM Ladle

Plant: BSL, Shop: SMS -2 (BOF –CCD), Yr.: 2023-24

Parameter	Data
BOF Cap.	300 T
BOF Tap Temp. (1660 - 1700°C)	99.8%
Slag Splashing of Heats (BOF)	>95% heats
On Line Purging (Ar)/% heat	100
SSM Route	LF
LF – Treatment (% heats)	100
Casting Time (minutes) (Blooms/ slab)	56
Metal Holding time in Ladle(Avg.)	120 – 150 , minutes
Ladle Return Time (minutes) (Casting end to tap start)	40 - 60
Ladles in circulation / Day	8 – 9 Nos.
Slag Basicity	1.8 – 1.9
Steel Killing	Al/ Si
Ladle Life (Heats) – Avg.	99.5

Table No. 4(c) -- Operating Regime of 165T –BOF & 165T - SSM Ladle

Plant: TSL, JSR (Shop LD -2), Yr.: 2023-24

Parameter	Data
BOF Cap.	165T
BOF Tap Temp,(°C) - % heat	> 1700°C – 1% 1660 - 1700°C – 30%
Slag Splashing of Heats(BOF)	25%
On Line Purging (Ar)	100%
SSM Route	LRF/ RH /Direct
LF – Treatment	90% of heats
Casting Time (minutes	55
Ladle Return Time (minutes)	50
Metal Holding time in Ladle	100 minutes
Heats/Day / Ladle	6 nos.
Slag Basicity	3.0
Steel Killing	Al-Killed
Ladle Life (Heat)	161.0

Table No. 4(d) - Operating Regime of 100T –EAF & 100T- SSM Ladle

Plant: JSPL, Raigarh, Yr.: 2023-24

Parameter	Data
EAF/NOEF Cap.	100T
EAF/NOEF Tap Temp,(°C)	1660 - 1700°C
Slag Splashing of Heats(EAF)	N/A
Steel Ladle Cap.	100T
On Line Purging (Ar)	100% of Heats
SSM Route	LRF/VD/RH
% of Heats through LF -RM	5.4
Casting Time (minutes)- Ladles	40 - 60
Ladle Return Time (minutes)	85
Metal Holding time in Steel Ladle	150 minutes – Avg.
Heats/Day / Ladle (Nos.)	5 - 6
Slag Basicity	3 – 4.5
Steel Killing	Al/ Si
Steel Ladle Life (Heats) – Avg.	111.7
Steel Ladle Life (Heats) - Calculated Avg.	133.3

Linking with the above stated stabilized operating parameters of the steel plants, the potential availability of the expensive residual furnace lining refractories are indicated plant wise in Table No. 5(a) to 5(d) for these steel plants.

Estimated potential of re-using of Residual Lining of Reft.(MgO–C,AMC) from BOF & SSM Ladles in Million tonnes Steel Plants of India

Table No. 5(a)

(Plant: DSP, Shop: BOF-CCD), Yr.: 2023-24

Process Unit(s)	VesselLife (Heat)	New Working Lining (mt)	Lining Brick qualty	Residual lining at life end (mt)	usefull for recycle (%)
BOF (130T)	6,106	498.2	MCB & AMC	90 ± 10%	18.1
SSM Ladle (130T)	72.4	23.2	-do-	4 ± 10%	17.4

Table No. 5(b)

(Plant: BSL, Shop: SMS-2 (BOF-CCD), Yr.: 2023-24

Process Unit(s)	VesselLife (Heat)	New Working Lining (mt)	Lining Brick qualty	Residual lining at life end (mt)	usefull for recycle (%)
BOF (300T)	4549	851	MCB & AMC	140 ± 10%	16.5
SSM Ladle (300T)	99.5	65	-do-	9 ± 10%	13.8

Table No.5(c)
(Plant: TSL,JSR, Shop: LD-2) , Yr.: 2023-24

Process Unit(s)	VesselLife (Heat)	New Working Lining (mt)	Lining Brick qualty	Residual lining at life end (mt)	Usefull for recycle (%)
BOF (165T)	7,535.0	420.0	MCB & AMC	75 ± 10%	18.0
SSM Ladle (165T)	161.0	33.0	MCB & Spinnel	4 ± 10%	12.1

Table No. 5(d)
(Plant: JSPL, Raigarh), Yr.: 2023-24

Process Unit(s)	VesselLife (Heat)	New Working Lining (mt)	Lining Brick qualty	Residual lining at life end (mt)	Usefull for recycle (%)
EAF (100T)	777 -1225	150	MCB & MGT	25 ± 10%	16.7
SSM Ladle (100T)	111.7	23	MCB & AMC	3 ± 10%	13

In addition to the potential of re-cycling of residual steel plant(s) furnaces linings as detailed above, the Table No. 6 given below gives a consistent over view of the total utilization of used / salvage refractories by engineering of product mixes for raw-materials savings and energy efficiency aiming towards total sustainability.

Table No.6

Refractory Arising from Steel Plant Furnaces & their Cost-Effective Uses

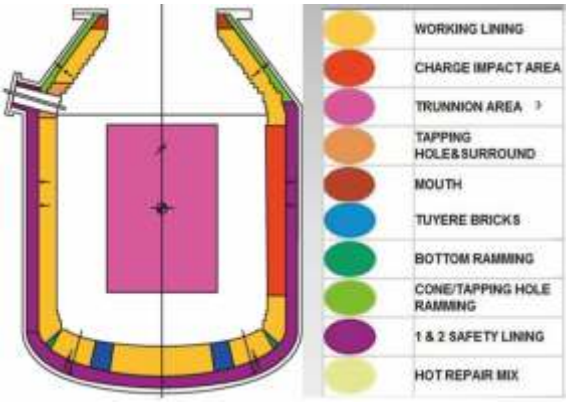
Processing Fces. In sequences	Types of Reclaimed Refts.	Used in End Refts. Practice/ Products	Recycled by	
			Steel Plant	Reft. Makers
Coke Oven Batteries (Recovery & Non-Recoverytypes)	Dense Silica	Silica Spray Mix	No	Yes
	Fire Clay	Alumino-Silicate Spray & Patching Masses	No	Yes
		Fire-Clay Bricks	Secondary Sales	Yes
BF & HB-Stoves	Carbon	HM Troughs/ Runners (Back-up lining)	Yes, in practice	No
	Silica (HB - Stove Top)	Road Making	Yes, in practice	No
	High –Alumina	HA Bricks & Castables	Secondary Sales	Yes
	Fire Clay	Fireclay Bricks, Shapes (as Grog) & Castables	Secondary Sales	Yes
Torpedo & HM Ladles	High- Alumina Bricks	HA Bricks (as Grog) & Castables	Secondary Sales	Yes
	Dense Fireclay Bricks	Fireclay Bricks (as Grog) & Castables	Secondary Sales	Yes
BOFs	Mgt./ MCH MgO-C	Mgt./MCH Bricks	Secondary Sales	Yes
		MgO-C Bricks	Secondary Sales	Yes
		Mgt. Ramming Mix.	Consumed in used	Yes
		Mgt./MCH Spray Mass/Gun Mix.	Consumed in used	Yes
EAFs	Mgt.	Mgt. Brick	Secondary Sales	Yes
	MgO-C	MgO-C Brick	Secondary Sales	Yes
		Mgt. Ramming & Gunning Mixes	Consumed in used	Yes
Induction Fce. (Secondary Steels)	Silica	Can't be used	No	No
	MCH	MCH Ramming Mass	Scantly Used	No
	High Alumina	HA Ramming Mixes	Reproces-sed & used	No
AOD	Mgt.	Mgt. Ramming Mix	Scantly Used	Yes
	*Mag Dolo & Dolomite	Steel Ladles, VAD Ladles, etc.	a) Cut to size& used judiciously in Steel Ladles	No
			b) Part Quantity to Secondary Sales	Yes
Reheating Fces.	High Alumina Bricks/ Shapes	HA Brick (as Grog) & Castables	Secondary Sales	Yes
	Fireclay Bricks/ Shapes	Fireclay (as Grog) & Castables	Secondary Sales	Yes
Slide Gates & Flow Control Products (MBS, SHD, SEN, etc.)	Al_2O_3-C	HA/Zr Castables	Secondary Sales	Yes
	Al_2O_3-ZrO_2-C & ZrO_2 (from Nozzle)	FCP (with residual Carbon%)	Secondary Sales	Yes

*Mag-Dolo & Dolo reft. are normally cannibalized by user plants.

Steelmaking Furnaces with potential for generating salvaged Basic Refractories.

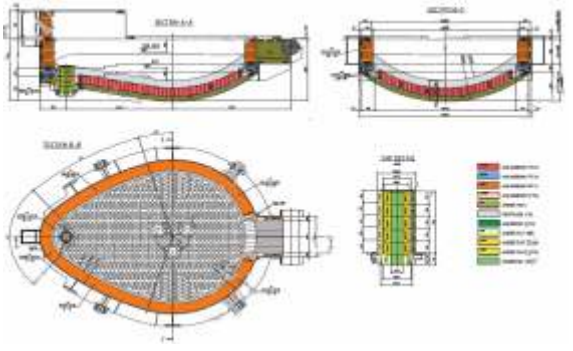
This section deliberates on the trend of used refractories utilization as pre-sintered dense graded aggregate along with the fresh raw materials, while preparing the batch mixes for varied categories of products. The products are series of Magnesia-Carbon refractories, basic ramming mixes, etc. for selective uses and some FCP items also.

Fig Nos. 7, 8, 9 & 10 are showing BOF, EAF, SSM Ladle and Con-cast assembly, from which the steel plants and refractory manufacturers are reusing worn out refractories.

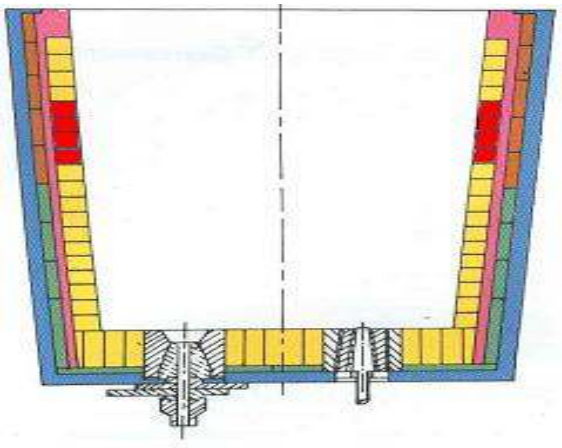


(Life 5000-6000 Heats)

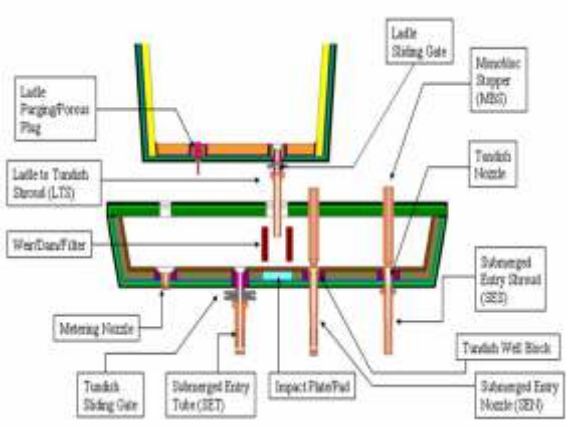
Zones of BOF Lining contributing to reuse of Refts. - Fig. No. 7



(Life 1400 – 1800 Heats) Zones of EAF Lining contributing to reuse of refts. - Fig. No.8



(Life 130 – 160 Heats) SSM Ladle Lining contributing to reuse of refts. after campaign end - Fig. No. 9



Scope of Refts. Recycling from Concast Assembly - Fig. No. 10

Engineering of Basic Refractories with Recycling Efforts – Case Examples

This section briefly describes on the efforts of waste refractories utilization for value addition:

- 130T-SSM Ladles of DSP – SAIL – Performance & Reft. arising
- Making of Basic Gunning Mix by reprocessing of salvaged refractories
- Cost effectiveness of FCP items – Active developmental work is continuing at the manufacturing ends.

In CCD of DSP for lining of metal zone, MgO-C bricks with 9-10% graphite are used, which could withstand severe operating conditions involving arcing, attack of highly corrosive slags, degassing of metal to make quality steels, through LF & VAD routes. The process parameters are given in Table No. 4(a) and Table No.7 gives the characteristics of MgO-C Brick for metal zone of this ladle or similar SSM ladles.

In the Zonal Lining format of the secondary Steel Ladle, some qualities of MgO-C brick, which is engineered by adding 16% of re-cycled MgO-C is used as a practice in steel plants of India. The composition of such re-designed brick is given in Table No. 8 & 9 and the lining profile of new ladle is shown in Fig. No.9.

Table No.7

Characteristics of MgO-C – Metal Zone brick (130T Ladle-DSP)

Parameters	Source-A
AP (Vol%)	3.22
BD (gm/cc)	3.02
CCS (kg/cm^2)	360
Coked AP (Vol%)	8.4
Coked BD (gm/cc)	2.98
MgO in Magnesia used (wt%)	96.5
Fixed Carbon (wt%)	10.6

Table No.8

MgO-C brick – Batch Composition (wt %), with no addition of salvaged MCB:

Sl.No.	Items	Grain Size(mm)	(% in batch)
1.0	High Purity DBM (MgO- 96/97%)	3 – 4	25.0
2.0	-do-	1 – 3	45.0
3.0	-do-	0 – 1	16.0
Total			86.0%
4.0	Flaky Graphite (FC-92/94%)	Fines	9.0
5.0	Extra –hard Pitch	-do-	1.0
6.0	Metallic Al- Powder	Atomised	1.5
7.0	Phenolic Resin (Bonding)	Liquid +Powder	3.0
Total			100.5
Formed MCB bricks baked at 180-200°C (reducing atmosphere)			

Table No.9

Mag-Carbon brick – Batch Composition (wt %) with addition of Salvaged MCB:

Sl.No.	Items	Grain Size(mm)	(% in batch)
1.0	High Purity DBM (MgO-96/97%)	3 - 4	25.0
2.0	-do-	1 - 3	35.0
3.0	Salvaged MCB(grained)	-do-	10.0
4.0	High Purity DBM (MgO-96/97%)	0 - 1	10.0
5.0	Salvaged MCB (micro-fined)	-do-	6.0
6.0	Flaky Graphite (FC-92/94%)	Fines	9.0
7.0	Extra –hard Pitch	-do-	1.0
8.0	Metallic Al-Powder	Atomised	1.5
9.0	Phenolic Resin (Bonding)	Liquid +Powder	3.0
Total			100.5
Shaped MCB bricks baked at 180-200°C (reducing atmosphere)			

Making of Basic Gunning Mix by Reprocessing of Salvaged Refts.

It is feasible to make basic semi-dry gunning mass for hot maintenance of Hot metal Mixer, BOF & EAF by processing of salvaged Mgt, MCH (as available) & MgO-C, as detailed in the preceding section. The characteristic of such product developed in steel plant (RMP) / manufacturing plant is placed in Table No. 10.

Table No. 10

Characteristics of Developed Basic Gunning Mix (MgO + MgO-Cr2O3 as base & recycled basic mass)

a) Dry Physical Properties

Screen Analysis (Wt. %)	
BSS +5 (3.40 mm)	4-6
-5+16 (1.0 mm)	27.0-29.0
-16+60 (0.5 – 0.25 mm)	26.0-28.0
-60+100 (0.25-0.15 mm)	7.0-9.0
-100 (0.15 mm)	34.0-37.0
Packing Density (gm/cc), min	2.35
Shelf Life, max.	45 days
Setting Characteristic of mass	Initial setting at 600-800°C
Chemical (Wt. %)	
LOI	2-3
MgO	60-70
Cr_2O_3	10-12
Fe_2O_3	16-18
Al_2O_3	1.2 max.
CaO	0.5 max.
SiO_2	6-8
Additives:	
BOF Slag fines	3-5
Hard Pitch (mp 100-105^{0}c)	5
Chemical Binder (Mg-Base)	5-6

*Depending on end uses, the grain distribution of the mass will be modified

b) Test properties on Dried/Fired Sample*

Para-meters	Dry	Firing of cylindrical sample for 2 hrs. at			
		500 °C	1000 °C	1400 °C	1600 °C
PCE (ASTM)	+33	-	-	-	-
CCS (kg/cm2). min.	80	70.0	8.0	30.0	90.0
Linear Change (%)	nil	-0.50	+0.26	nil	-2.1
Sintering Temp. °C, (Approx.)	-	-	-	1350-1400°C	-

*Test Sample Size = 50 mm dia X 45 mm ht (By ASTM sand rammer with addition of 5% hot water)

i) Tonnage carbon steel, stainless and alloy steel works have their process specific refractories waste utilization mode, using their in-house RMPs, besides selling the arising to the refractory manufacturers for their recycling. Currently, plants are striving to achieve a zero-emissions operation by 3R-module i.e. Reduce, reuse and Recycle concept.

ii) Used refractories are secondary cheaper sources of expensive raw materials and this helps in conservation of mass and energy. It may be observed that 95-98% purity MgO needs approx. 12-14.0 GJ/mt of energy for their calcinations (single/ double stage). Any recycled basic component will save energy to that extent and add values to the environment.

iii) Currently, leading manufacturers have developed and stabilized the process tech. practices for cannibalization of High Alumina, Alumino- Silicate, MCB, Alumina-Carbon, etc of worn out refractories for judicious use in metallurgical process units. Parallely, Steel plants are actively working for reprocessing of their used FCPs along with the leading refractory makers.

Acknowledgements

The authors sincerely thank Mr. Anirbandip Dasgupta, Sr. Executive Officer, IRMA for his continued encouragement in these developmental activities.

During structuring of the paper, the invaluable help rendered by Mr. Susanta Sarkar, Ex G.M., SRU- SAIL is gratefully acknowledged.

References

1. Pvt. Communications with Mr. D. Ghosh, Ex-COO, SRCL-SAIL, (Aug, 2023)
2. Plant Process Parameters & BOF/SSM Ladle Reft. Inputs, Operating Committee Meeting on Refts., Bhilai (6 – 7th March,2024)
3. Dasgupta, Kr. Ajay & Ganguly, Ashim – Tech. Prestn. on Management of Waste Reft. Recycling, National Conf. – Industrial Ceramics: Challenges, opportunities & Sustainability, CSIR – CGCRI (13th – 14th June, 2024).

GLIMPSES FROM THE PAST:

PRESENT ECONOMIC CRISIS AND SOME NEW THOUGHTS ON] THE RESEARCH, DEVELOPMENT AND APPLICATIONS FOR THE REFRACTORIES IN THE NEXT DECADE

A.K.ChattopadhyayJoint Managing Director-Tata Refractories Ltd. & Chairman-IRMA

Introduction

The current world economic environment is turbulent and frightening. This has come from a consequential irrational exuberance, a dash of greed and failure to acknowledge the complexities of over-clever financial instruments. To understand this crisis and also to face the challenges of this uncertain world let me start with the story of "BLACK SWAN". Before Australia was discovered it was believed that all Swans are white as there was no evidence of any other kinds of Swan in our Hemisphere. The Dutch explorer 'Willem De Vlamingh first discovered in the area which is now Perth in the western Australia in the 17th century the Black Swan. First they did not believe their eyes as Swans were by definition white. The Black Swan phenomena is principally concerned with the problems of uncertainty and knowledge. The Black Swan phenomena has three attributes:

(1) It is outside the realm of normal expectation

(2) It must make a huge impact

(3) It must be seen to be logical and explainable after the fact.

The present global financial crisis is exactly the same and we can expect in next 12 months

(a) The global economy is likely to enter a period of negative growth

(b) Equity markets are expected to be weak in the near to medium term

(c) Lower demand trends

(d) Lower prices

(e) Lower credit availability

(f) High cost of capital &

(g) Currency volatility.

We are certainly living in a "VUCA" world (Volatile, Uncertain, Complex and Ambiguous).

This is not a time to berate globalisation and build a fortress around our economy. Rather it is a time to sally forth and look for opportunities to make our presence felt on the global financial stage. 20 years ago we could never imagine the impact of inter-net and the true emergence of China. The winds of change continue and moving relentlessly faster and assuming strong proportions. In the next 10 years we may also see such significant developments as widespread cheap solar power, wearable computers, targeted drug delivery or green manufacturing. Looking further ahead we may see world changing breakthroughs which could allow us to build computers that learn like human or we can rebuild living organisms to fight disease, make bio-fuels and solve industrial problems. These are not dreams but innovations that scientists and engineers across world are actively working on making reality. These changes have the potential to profoundly impact how we live and work, what business model should be followed, what social net works we pursue, what products and services we use. More than ever we have the power to create and set our destiny.

The forces that are impacting our world:

(a) Shifting economic power

(b) Changing labour landscape

(c) Growing pressure on natural resources

(d) Changing technology landscape

(e) Changing industrial landscape

(f) Changing consumer landscape.

In a country like India we are going to gain into two important ways from the present crisis. First like many other emerging markets we may go through some pain but it will be minimal. We may not grow at the rate of 8% but still we will be one of the world's fastest growing economies. Thanks to our Reserve Bank for relative insulation.

Secondly this crisis could hold the seeds of a great opportunity. Wall street Giants have fallen and there is a vacuum, the Indian financial sector with its newfound confidence must be among these. Globally there is still a lot of liquidity outside the western world, particularly in west Asia and thus it is expected that focusing on the following parameters such as:

(a) Financial conservation

(b) More focus of risk adjusted valuation of asset classes

(c) Focusing more on balance sheet and

(d) With the elimination of risk of regulatory clamp up, we are sure to manage the present crisis.

Refractories though poised for a big growth have always remained squeezed between the raw material suppliers and steel makers. The negotiating power of the refractories makers is poor mainly due to their size as it cater to the industries which are far bigger in sizes like steel, aluminium, cement etc,. To add to this, the industry is facing countless difficulties both in terms of increasing raw material and other input costs as well as the availability. The industry in its pursuit of sustenance have to get a better realization, make more profit for providing long term service and develop newer products though research and development and also through newer application technologies. Let us now dwell on the subject of some future research, development and application methodologies in the refractories horizon.

Iron Making Area

1. *Torpedo Ladle*:

- For effective dephospherisation the most suitable lining is Al_2O_3-SiC–C brick and the performance of these bricks can be improved by any one of the following methods.

(a) Reduce oxidation by adding ß Al_2O_3

(b) Minimise joint corrosion by adding MgO thereby causing spinel formation.

(c) Lowering the thermal conductivity by suitable selection of amorphous carbon material.

(d) Addition of metallic aluminium and borosilicate glasses.

– FEM analysis has been developed to determine the accurate temperature loss resulting to occurrence of mechanical stress.

– Possible opening of the joints at the hot face.

– Designing of the mouth castable should consider

a) Shear thinning characteristics

b) Should flow like Bingham plastics.

2. *Trough*:

Anhydrous mass –

A specially developed aluminium power is added to the composition of the ramming mixes Al_2O_3-SiC–C and it acts both as a sintering agent and antioxidant. After melting Aluminium react with CO and CO_2 to get a newly formed Al_2O_3 that are helpful to improve strength density and structure.

Castable –

Normally lined with low cement Al_2O_3–SiC–C castable and generally the wear is characterized by two locally generated corrosion one between Metal–Slag interface (ML-metal line) and the other Slag – Air interface (SL – slag line).

- Studies required to evaluate the SiO_2 content and its influence on the corrosion resistance arising out of the SiC oxidation.

- Some studies have also been done on the influence of the spinel addition but no

quantitative data are available. Microstructure study of the spinel addition and the corresponding behaviour towards corrosion resistance improvement will be an interesting area for further development.

- Another important study should be grain size distribution of the components as very often it has been seen that inhomogenity causes lowering of mechanical strength, increase of apparent porosity and thus non uniform chemical composition and phase distribution.

Steel Making Area

Both for ladle and converter MgO-C bricks are still the widest choice and several work at different laboratories are being carried out to improve the properties of MgO-C bricks starting from improving the purity and crystalinity of MgO and finally to density increase.

- Recent studies are on the on the C- side i.e. specially processed pitch or changing the morphology of the C being used.
- Another area of development being the change in the metal additive and here specially developed Boron alloy powder i.e. the best additive showing improved oxidation resistance.
- A possible study can be to use MgO-CaO clinker as CaO is more stable than MgO at high temperature in contact with carbon.
- However, break through improvement in converter have been achieved by flame gunning repair. This is primarily a technique that involves simultaneous melting of a refractory powder and gunning it on the hot surface. Since the gunned repair material is dense and fused directly on the worn out surface excellent results are achieved.
- Study of the factors that control the secondary spinel formation in direct bonded Mag-Chrome refractories being used in RH degasser. It improves the necessary hot strength and corrosion resistance.

Monolithcs

- To develop cements which will enable castables to be adjusted to a normal setting behaviour and will avoid the variability and uncertainty of setting specially during winter time.
- To develop defloculants which will provide castables with prolonged working time and improved flowability compared to polyacrylates and polyphosphates being commonly used now – a - days.
- Matrix interaction study to understand fully the mechanism of flow delay and initial stiffening arising out of the interactions of phosphates, fume silica and calcium aluminate phases.
- Study of the total amount of alumina and the ratio of line to ultra line alumina powder to interpret the strength of different castables.
- In magnesia based castable with Al_20_3 in the matrix the rate of spinel formation and the temperature range will determine the densification of the continuous spinel matrix which will determine two important characteristics of the spinel castable:

a) Corrosion resistance

b) Thermal shock resistance.

- Binders are the harmful component of the refractory castable. While no cement castables have been developed they suffer regularly from a distorted rheological behaviour.
- One possible developmental area may be to obtain binding properly by a mechanical and chemical processing combined (mechanical dispersion and chemical interaction processes combined).

Shotcreting

It is the process by which castables are pneumatically projected at high velocity onto a surface. One aims to get the benefit of both the castable and gunning technique in one go. The main essence of the process is suitable

judgement of the accelerator as it is normally added at the nozzle. Refractory mixes for shotcreting are often designed to be self flow, transportable or sprayable. Accurate accelerator dosing is essential.

The most important aspect of obtaining a quality lining through shotcreting route are:

a) Proper self flow castable consistency

b) Use of high air pressure.

c) Suitable dose and as minimum as possible quantity of accelerator.

d) Proper anchoring

e) Proper scaffolding

f) Proper nozzle adjustments

Today suitable mixes have been developed to shotcrete cement rotary kilns, Aluminium melting furnaces, waste incinerators etc, etc. Lastly on the monolithics one last word and probably that is the dream of all unshaped refractory producers to have a Mag– Carbon castable to replace Mag-C brick in ladles, converters etc. There are activities all around across the globe but real progress have not been met yet. The increase in carbon content normally reduces the strength of the castable. Development work should possibly be a complete new type of carbon and i.e. why we need to work with the carbon producers and on some chemical defloculent as well. All developments of refractory technology should aim towards environment protection and points to consider for that are reducing the refractory emissions for which it requires an improvement of service life of the furnace and reduction in refractory consumption. For this it is required to focus on the development of:

1. Technologies to repair effectively partial worn areas prior to complete replacement of the lining using monolithic refractories with an extremely good durability.

2. Progress on sequential repairs that will allow continuous relining to be done without discarding the remaining lining.

Other Industries

Cement

Main concern area is the burning zone and here we all know a variety of influence contribute to the wear of the refractories and cause either a chemical, mechanical and thermal loading of the kiln. While mostly bricks have been developed to take care of the mechanical and thermal loading chemical aspect, are still bothering the operators and most probably the decisive factor is DS index (degree of sulfatisation).

$$DS = \frac{SO_3 + Cl}{Na_2O + K_2O.}$$

and the developmental efforts need to be to optimise the lime content of the binder phase and the alkali chromate of the magnesia chrome refractories.

- Three other new types of refractories are being developed.

(1) Magnesium orthotitanate (Mg_2TiO_4) which is a spinel and after reaction with cement clinker $CaTiO_3$ is formed which provide good coating formation and $CaTiO_3$ is also a stable phase in contact with Portland Cement.

(2) Magnesia orthostannate refractories by incorporating 90% SnO_2 powder in M.A. spinel. Here MgO decreases the volatility of SnO_2 due to formation of **Mg_2SnO_4** and also the resultant material shows higher corrosion resistance compared to magnesia chrome refractories.

(3) For developing flexible structure i.e. to absorb the stress developmental work is required to produce bricks with MgO-CaO-ZrO_2. This will not only improve the corrosion resistance and will provide good coating adherence but will also eliminate the problem of hazardous hexavalent chrome compounds.

Aluminium

Anode baking

The main mechanism of deterioration of refractories has to be identified. Early works have

shown that the deterioration occurs in the matrix and the XRD studies have shown that this is due to an increase of Na-rich liquid phase. How to reduce the liquid during the corrosion of sodium gas is actually the challenge of the refractory researcher.

Aluminium Cast house (Melting and holding furnace)

There are plenty of commercially available castables (both conventional and low cement) having non wetting characteristic combined with excellent chemical / mechanical properties with good thermal shock resistance is available and are in use. Further research required to improve the properties like:

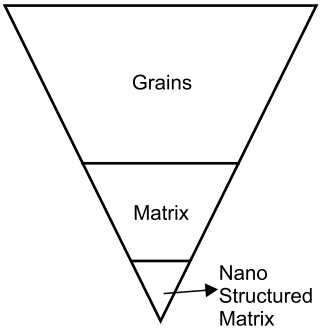
a) Abrasion resistance

b) Superior aluminum resistance even at high temperature.

c) Better and improved thermal shock resistance.

Nano Tech Refractories

Thermal shock resistance and corrosion resistance conventionally require opposite characteristics and nano tech refractories essentially satisfy both these characteristic.



The whole idea is to control the microstructure. A whole host of research is going on and addition of nano particles will revolutionalize the refractory technology altogether. Grossly saying it acts in two ways:

1. The nano particle – They are consisted of mono spheres and improve the properties like elasticity and strength.
2. The control of molecular structure as the particles have many small pores of about several hundred nanometers.

Refractory research, development and application methodology have to concentrate on the following aspects:

1. High temperature tensile and compressive behavior of the lining.
2. Characterization and modeling of the thermo-chemical bahaviour of lining through FEM
3. Creep and plasticity at high temperature.
4. During heating always refractory linings are exerting important pressure on the metallic part of the structure and leading to lining cracks. Study of the structural designs are thus important by adopting multiscale approach
5. Thermal stress studies of the lining are important again with FEM.
6. Interaction between refractory material and the steel heat as for the cleanliness of the steel total oxygen content should be extremely low.
7. Low nitrogen content, low hydrogen content and low C- pick up – these studies are essential as this will impact the steel heats.

Finally we must protect our Environment and hence Recycle and Reuse is a must. In conclusion I may add that refractories cost is about 8% of the total cost of steel production and there is good possibility of further reduction of the specific consumption of refractories in Steel industry, Cement industry, Aluminium industry etc, etc and it would be through monolithics and special products. The leadership team has to decide which products and services it feels passionate about and then formulate the vision of R&D.

This keynote address was given at the International Seminar on Refractories organized by Tata Steel & Indian Ceramic Society (Jamshedpur Chapter) on 10th November 2008.

STATISTICS

		2023-24	
HSN code	IMPORT OF REFRACTORY RAW MATERIALS	QTY(mt)	(Rs.Lakhs)
25083010	Fire Clay (Non-Plastic)	0.0042	6.20
25083030	Fire Clay (Plastic)	0.0000	0.00
25083090	Other Fire Clay NES	0.0000	154.90
25085010	Andalusite	14.454	8,472.10
25085021	Kyanite Crude other than Calcined	1.320	641.17
25085022	Kyanite Processed other than Calcined	0.3920	90.69
25085023	Kyanite Calcined	0.1512	101.78
25085031	Sillimanite Lumps	0.0000	0.0000
25085032	Silimanite Fines (Incl. Sillimanite Sand)	0.0054	6.320
25085039	Other Sillimanite NES	0.0063	24.97
25086000	Mullite	11.3903	3,843.79
25199010	Fused Magnesia (Natural)	67.441	32,401.02
25199020	Dead-Burnt (Sintered) Magnesia	203.53	55,228.16
25199030	Magnesum Calcined NES or included	76.6061	20,950.95
25199040	Magnesium Oxide	67.7502	20,358.69
25199090	Other Magnesium W/N pure	56.9809	19,053.42
26060010	Bauxite (Natural) not Calcined	4,376.72	238,339.28
26060020	Bauxite(Natural) Calcined	126.0821	43,876.68
26060090	Other Aluminium ores & concentrates	1.31472	419.10

Source: Government of India, Ministry of Commerce and Industry

ISR 2024

The 9th International Symposium on Refractories

Oct. 15–18, 2024 Chengdu, China

The Ninth International Symposium on Refractories (ISR2024), organized by The Chinese Society for Metals, The Chinese Ceramic Society, and Sinosteel Luoyang Institute of Refractories Research Co., Ltd. will be held in Chengdu, China on October 15–18, 2024.

International Symposium on Refractories (ISR) is a serial international symposium and has been held successfully for eight sessions. ISR2024 will provide a good opportunity for researchers, manufacturers, suppliers and users around the world to review the progress and achievements made in recent years.

Manuscripts, Proceedings and Presentation

Abstract shall be submitted before July 31st, 2024 while manuscripts shall be submitted before Sept. 15th, 2024 through the conference website (www.isr2024.com). During submission, please select the field of the manuscript (topics of the conference) and presentation preference (oral or poster). The presentation type (oral or poster) will be finalized after the manuscripts are reviewed. After assessment, all the accepted manuscripts will be published in the conference proceedings in the form of U disks.

Conference Schedule

Date	Morning	Afternoon	Evening
October 15th	——	Registration	Registration
October 16th	Opening ceremony Plenary Session	Plenary Sessions	Banquet
October 17th	Parallel Sessions	Parallel Sessions	——
October 18th	Parallel Sessions	——	——

Registration

Registration Fee	Before July 20th, 2024	From July 20th to October 14th, 2024	Pay On-site
Regular Participants	USD 650	USD 750	USD 850
Students	USD 450	USD 550	USD 650
Accompanying People	USD 100		

**Note: Students are requested to submit the copy of their student ID before payment.*
The registration fee for accompanying people only covers banquet.

Conference Venue and Hotel Reservation

The conference will be held in Chengdu, the capital of Sichuan Province. The city is renowned for its relaxing lifestyle and delicious food. It has many historical sites and cultural landmarks. Meanwhile, Chengdu remains one of the key economic, cultural, and transportation center in southwest China, with remarkable progress in technology and innovation in recent years. Chengdu is also famous for Panda Breeding and Research, attracting people from all over the world. Howard Johnson Agile Plaza Chengdu is the conference site. It locates in the Tianfu New district adjoining to the Luxehills International Community and Western China International Expo City. It is 30 minute-drive from Chengdu Airport, and 20-minute drive from the Chengdu South Railway Station.

Sponsorship and Exhibition

Sponsorship and exhibition opportunities are available. The exhibition will be organized during the conference. Refractory raw materials and products, production and testing equipment, as well as technologies and methods related to the latest developments in the field of refractories are welcome to exhibit at the conference site. Please contact the conference secretariat for booth reservation and sponsorship.

Contact Information

Ms. YU Lingyan
Refractories Committee of The Chinese Society for Metals
Sinosteel Luoyang Institute of Refractories Research Co., Ltd.
Add: No. 43 Xiyuan Road, Luoyang 471039, China
Tel: +86-379-64205969
Fax: +86-379-64205970
Ms. LIU Fang
The Chinese Society for Metals
Tel: +86-10-65211205
Fax: +86-10-65124122
Email: isr2024@csm.org.cn

Technical Articles for IRMA Journal

Indian Refractory Makers Association extends an earnest request to all readers of IRMA Journal for their co-operation in providing technical notes and articles concerning raw materials development, introduction of novel inputs, refractory products and their design, selection, application engineering and performance for a better exchange of technical information and experiences amongst producers and user of refractories. The full paper can be mailed to support@irmaindia.org with the title "Technical Article for IRMA Journal".

The Guidelines for the prospective authors are reproduced below:-

GUIDELINES FOR TECHNICAL ARTICLES FOR THE IRMA JOURNAL

The authors submitting technical articles for publication in the quarterly IRMA Journal (normally published in April, July, October and January each year) are requested to follow the following guidelines:-

1. The technical article should be in camera ready condition on standard A4 size paper and should be sent in soft copy in MS-Word document format by email at support@irmaindia .org

2. The paper should not normally exceed 5 printed pages, including illustration (photos, graphs, figures, table, etc.) in two columns.

3. The print area shall be 16cm width X 24.5 cm height.

4. The title of the paper is to be in 14 point "Arial" Bold and Italics, al Capitals, brief but informative e.g.

MINERALOGICAL STUDIES ON…

5. The authors name and organization shall be printed in 10 point "Arial" Italic, e.g. *A.Dasgupta*

6. The sectional or sub-heading should be 10 point "Arial" Bold, e.g. **Effect of High Temperature**.

7. The body typing should be 10 point "Arial" Normal, e.g. The factor affecting the lining life

8. References are to be numbered in chronological order as cited in the text and should be given in 10 point "Arial" Normal, at the end of the article. The format should be:- surname and name of the author first, followed by the title of the book/article, the title of the paper/ publication, volume number, issue number, page and year of publication.

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.

SADASHIVA REFRACTORIES LLP

Raw Material Elucidation

A FEW WORDS

ABOUT US

SadaShiva Refractories LLP 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 and Chamotte. We have been registered with GMDC and we have been allotted more than 3500mts of Raw bauxite per month under the quota system. Our company headquarters is located in Mumbai and plant operations with advanced captive Rotary – Kiln Calcination is located at Meghpar in Jamnagar.

OUR MISSION

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

CALCINED BAUXITE

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

CHAMOTTE

Chamotte is sourced from best quality captive mines having pure grade of china clay by the process of levigation.

CALCINED CLAY

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

CORPORATE ADDRESS
F 24, Sej Plaza, Marve Road, Malad West, Mumbai 400 064

PLANT ADDRESS
Plot No. 1 & 2, Survey No. 365 Vill.: Jogvad,
Tal.: Lalpur, Dist.: Jamnagar 361 280, Gujarat

marketing@sadashivarefractories.com
info@sadashivarefractories.com

Mr. Krunal Dalal : +91 90541 16583
Mr. Nandlal Samani : +91 95588 23340

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**